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Descriptions and Biology of Nine New Species of *Arpactophilus* (Hymenoptera: Crabronidae), with a Key to Described Australian Species

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Abstract.—The following new species of *Arpactophilus* are described: ***A. deakinus, A. platycephalus, A. similus, A. flavifrons, A. magneticus, A. kakaduensis, A transversus, A. termes,*** and ***A. hursti.*** This brings the total number of named Australian species to 22. An illustrated key to the females of described Australian *Arpactophilus* species is provided and a **lectotype for *A. steindachneri* Kohl is designated.** Biological information is presented for each of the new species plus *A. reticulatus* (Turner). Extended parental care and progressive provisioning are the hallmark of this genus, with known species displaying a range of habits from solitary (4 species) to possibly eusocial (a nest of *A. termes* contained 19 adults and 33 cells). *Arpactophilus reticulatus* appears to be the most generalized, and was found nesting in stem cavities of five plant species across a broad range of habitats. It was parasitized by a generalist eupelmid wasp, *Calosota* sp. Four species used empty galls of a gelechiid moth, *Sphaleractis parasitica* Meyrick, on geebung, *Persoonia falcata* (Proteaceae). Five other species nested in old beetle tunnels in slender twigs of various trees and shrubs. Psyllid nymphs were the usual prey, but *A. transversus* also preyed upon cicadellid nymphs. All species appear to have multiple generations per year where weather conditions permit.

Arpactophilus is an Australasian genus of predatory wasps remarkable among Apoidea (Melo 1999) for their high level of social behavior (Matthews and Naumann 1988). Presently, 13 species are recorded from Australia. However, material in collections indicate that there exists a spectacular array of more than 60 undescribed species (Naumann, unpublished). The genotype, *A. bicolor* Smith (1864), was described from Misool, an island near the western end of New Guinea, which remains the westernmost locality of the genus outside Australia. Menke (1989) described three new *Arpactophilus* species from New Guinea, and stated that there were several undescribed species represented in the collections of the Bishop Museum, distributed from New Guinea to Fiji, including New Britain, New Caledonia, and the Solomon Islands. Recently, Bohart (1999) described 17 new species from New Caledonia with a key to females from material taken by Malaise traps.

Bohart and Menke (1976) synonymized *Austrostigmus* Turner (1912) under *Arpactophilus*, commenting that the characters used by Turner to distinguish it from *Arpactophilus* were variable and intergraded with those of typical *Arpactophilus*. Menke (1989) reviewed the diagnostic characters of the genus and provided detailed notes on morphological variation present among the species. In addition, he placed it in a separate new subtribe of the Pemphredoninae, the Spilomenina, together with the closely related *Spilomena*, *Micros-*

tigmus, and *Xysma* (see also Menke 1997, p. 251).

This paper describes nine distinctive new Australian *Arpactophilus* and provides a key to females of all the named Australian species. Biological data for each of the new species plus one previously named are also presented.

METHODS

Morphological terminology largely follows Bohart and Menke (1976). Terminology for microsculpture follows Harris (1979) and Eady (1968). Biological studies were conducted on Magnetic Island, near Townsville, Queensland from October to December, 1998, in Deakin, a suburb of Canberra, A.C.T. in January and February 1999, and in Kakadu National Park, east of Darwin, Northern Territory in May 1999. Unless otherwise noted, all specimens and nests from this study are deposited in the Australian National Insect Collection (ANIC) in Canberra, Australia.

KEY TO DESCRIBED AUSTRALIAN *ARPACTOPHILUS* (FEMALES)

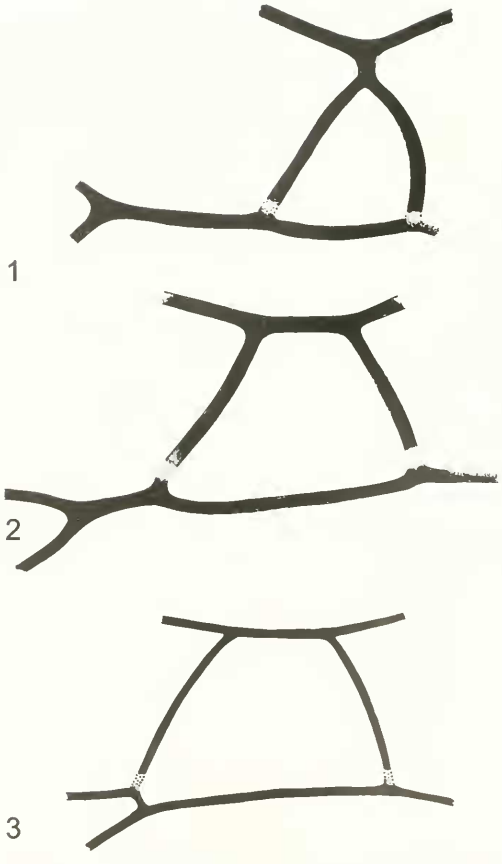
1. Second submarginal cell triangular **and** anteriorly appendiculate or stalked (Fig. 1) .... ***queenslandensis*** (Turner)
– Second submarginal cell trapezoidal or cubical, or if triangular, not distinctly stalked (Figs. 2 and 3) 2
2. Head strongly flattened; pronotum greatly elongated and mesosoma dorsoventrally strongly compressed (Figs. 17–19 and 21–22) 3
– Head globular to elongate, not at all flattened; pronotum transverse, not elongated and mesosoma not markedly compressed dorsoventrally 4
3. Clypeal free margin cream yellow to orange red; second submarginal cell trapezoidal .. ***similus*** **sp. nov.**
– Clypeus entirely black; second submarginal cell nearly triangular .. ***platycephalus*** **sp. nov.**
4. Body entirely black or dark brown, except occasionally tegula and/or pronotal lobe lighter 15
– Body (excluding legs and antennae) marked with yellow, red-orange, or cream, at least on the clypeal apical margin 5
5. Mesosoma at least partly red/orange 6
– Mesosoma entirely black, or at most with only the pronotal lobe lighter 7
6. Pronotum red/orange, contrasting sharply with black mesonotum .... ***ruficollis*** **(Turner)**
– Pronotum anterior to pronotal carina mostly black .... ***kakaduensis*** **sp. nov.**
7. Head marked with yellow or red/orange or cream color, at least on clypeal free margin 8
– Head entirely black 9
8. Lower face to middle of eyes yellow; gena extensively yellow .... ***tricolor*** **(Turner)**
– Yellow facial markings confined mostly to clypeus; gena with yellow restricted to region surrounding mandiblar socket .... ***flavifrons*** **sp. nov.**
9. Pronotal carina prominent, elevated, distinctly separated from mesoscutum, with anterolateral margins acutely angulate (Fig. 64); free clypeal margin distinctly cream colored .... ***hursti*** **sp. nov.**
– Pronotal carina low, sometimes thin and bladelike, closely appressed to mesoscutum, with anterolateral margin rounded; free clypeal margin black or nearly so 10
10. Body length less than 4 mm; vertex microreticulate to finely punctate; distance from lateral ocellus to eye distinctly less than distance between lateral ocelli (Fig. 33) .... ***magneticus*** **sp. nov.**
– Body length greater than 5 mm; vertex coarsely sculptured, often with prominent striation; distance from lateral ocellus to eye equal to or greater than distance between lateral ocelli (Fig. 4) 11

11. Frontal carina expanded into an acute projection on frons (Fig. 5) ..... ***arator*** **(Turner)**
– Frontal carina not forming an acute projection, although sometimes expanded blade-like between scapes 12
12. First recurrent vein received by first submarginal cell (Fig. 2) ..... ***sulcatus*** **(Turner)**
– First recurrent vein more or less interstitial or inserting on second submarginal cell (Fig. 3) 13
13. Mesoscutellum longitudinally striate (Fig. 6) ..... ***descrticolus*** **Turner**
– Mesoscutellum microreticulate with sparse setigerous punctures (Fig. 7) 14
14. Pronotal carina bladelike, distinctly separated from the mesoscutum ... ***steindachneri*** **Kohl**
– Pronotal carina closely appressed or barely separated from mesoscutum ... ***kohlii*** **(Turner)**
15. Mandible strongly angulate at base and broadened just before apex (Fig. 8) ..... ***mimi*** **Naumann**
– Mandible not as above, curved at base and gradually narrowing toward apex 16
16. Occipital carina complete dorsally (Fig. 53) 17
– Occipital carina incomplete, evanescent or interrupted dorsally 18
17. Pedicel length about half that of first flagellomere; clypeal margin not serrated; mesoscutal sculpture rugose with large, irregularly spaced, crater-like punctures (Fig. 9) ..... ***reticulatus*** **(Turner)**
Pedicel length subequal to that of first flagellomere; mesoscutal sculpture reticulate rugose (Fig. 57) ..... ***termes*** **sp. nov.**
18. Mesoscutum with distinct transverse carinulae (Figs. 47–48); gena strongly strigose (Fig. 45) ..... ***transversus*** **sp. nov.**
– Mesoscutum mostly finely punctate; gena sculpture variable, but not strongly strigose 19
19. Frontal carina raised, forming a translucent lamella between antennal scrobes ..... ***dubius*** **(Turner)**
– Frontal carina low, barely raised between antennal scrobes 20
20. Pronotal carina not especially raised, the anterolateral margin smoothly rounded, not at all projecting (Fig. 11); genal carina present ..... ***deakinus*** **sp. nov.**
– Pronotal carina strongly raised, anterolateral margin angulate; genal carina absent 21
21. Anterior veinlet of the second submarginal cell as long as 2r-m cross vein, the second submarginal cell nearly quadrate; stigma brown ..... ***glabrellus*** **(Turner)**
– Anterior veinlet of the second submarginal cell distinctly shorter than 2r-m cross vein, the second submarginal cell more trapezoidal; stigma yellow-brown ..... ***approximatus*** **(Turner)**

TAXONOMY

The ANIC collection of *Arpactophilus* has been sorted into over 60 provisional species, most of which are unique or represented by only a few specimens, usually females. Based on this material, Menke's (1988) comments on morphological variation within the genus can be augmented for the Australian fauna as follows.

Head shape varies from globular to quadrate to elongate and flattened. Postocellar area may be long or short, and broadly emarginate to transverse as viewed dorsally. Head sculpture, like that of the mesonotum and propodeum, varies from nearly smooth, to finely punctate, to distinctly striate, to coarsely rugose areolate. A well-developed carina may be present or absent on the gena. Clypeal free margin varies from broadly rounded to medially strongly emarginate. Labral free margin varies from entire to broadly bilobed to multidentate (2, 4 or 6 teeth). Frontal carina varies from strong to weak, and takes a variety of forms above the clypeus from dorsally bifurcated to lamellate to ventrally spinose. Additionally, it may extend a variable distance onto the clypeus and is sometimes flanked by submedian carinae.



Figs. 1–3. *Arpactophilus*, second submarginal cell of right fore wing. 1, *A. queenslandensis*. 2, *A. sulcatus*. 3, *A. desertícolus*. All drawn to same scale.

Pronotal collar varies from elongate (nearly as long as the mesoscutellum) to short, knifelike and closely appressed to mesoscutum. The transverse pronotal carina sometimes forms a bladelike lamella, either distinctly separated from mesoscutum or closely appressed to it. In dorsal view the carina may be straight, gently curved or broadly v-shaped, and the anterolateral margin vares from acutely angulate to gently rounded.

Forewing venation differs as illustrated in Figs. 1–3. In particular, the shape of the second submarginal cell varies from anteriorly broad, to narrow, to stalked, and the insertion of the first recurrent vein varies from the first submarginal, to interstitial, to the second submarginal. Menke (1988) also noted specimens from New Caledonia and Solomon Islands with only a single submarginal cell, and Bohart (1999) described four species with one submarginal cell from New Caledonia. There are at least two species in Australia with only one submarginal cell (one collected nr. Herberton, Qld, Australian Museum Collection, other from Surveyors Pool, WA in ANIC). Finally, the marginal cell varies from apically rounded to acuminate.

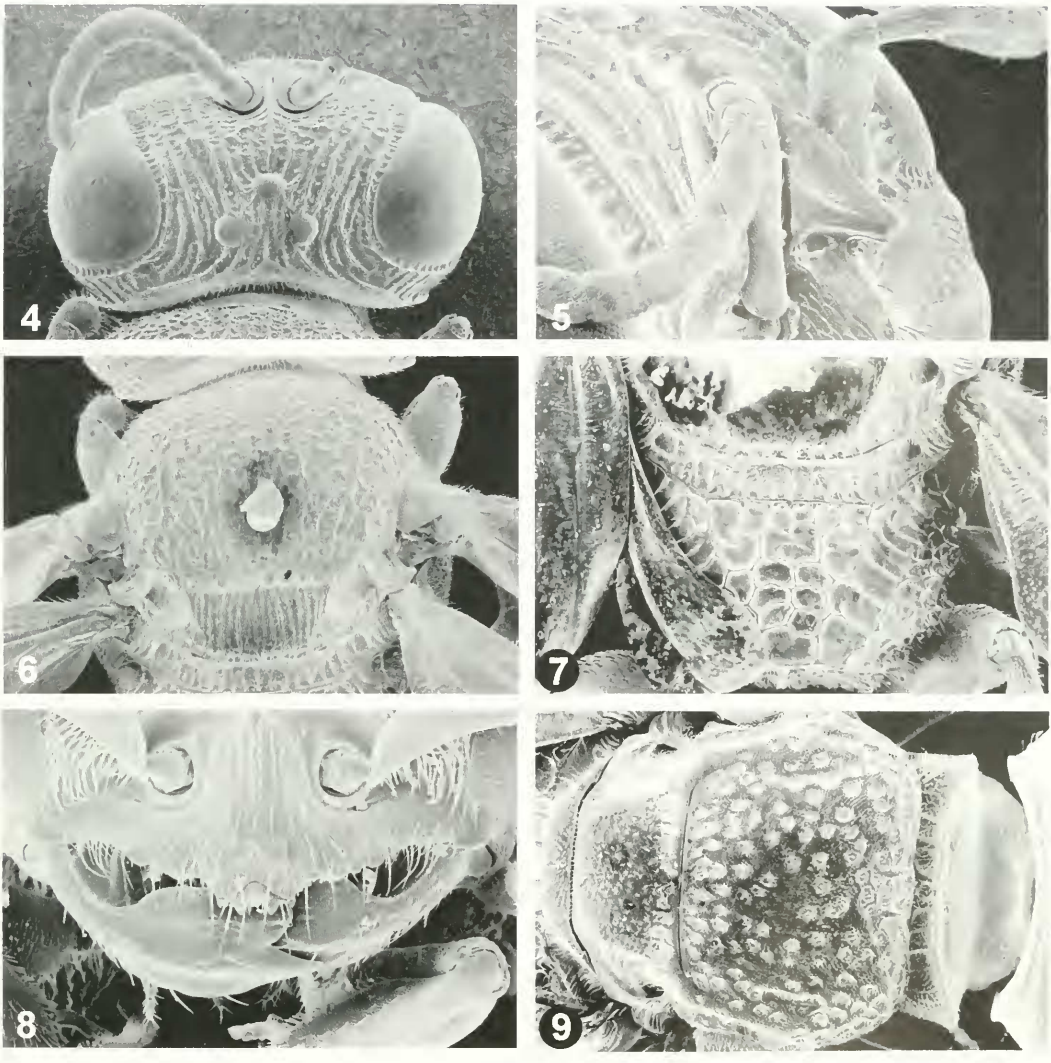
Terga I and II vary from smooth to sparsely punctate, to extensively microreticulate. Sternum VI in females varies from entire to subdivided into a mediosternite flanked by two laterosternites. Male genitalia have not yet received detailed study, as males are generally uncommon in collected material. However, Dollfuss (1983) found genitalic characters of considerable taxonomic value in the closely related genus *Spilomena*, which suggests that those of *Arpactophilus* will likely also prove useful.

Color varies from entirely black to pale except for a black head. Red/orange or pale straw occurs variably on either the mesosoma or metasoma or both. Many species have the lower face and part of the gena marked with yellow. So far none of the extensively pale species have been described. Interestingly, labels on several of these specimens state that they were taken at light.

Arpactophilus deakinus Matthews and Naumann, sp. nov.

(Figs. 10–16; Table 1)

Type material.—Holotype ♀, 35.19S 149.06E, Deakin, A.C.T., 24-i-99, R. W. Matthews, Bio. Note 187, in ANIC. Paratypes: 9 ♀♀, one ♂, all same locality as holotype (dates and notes are 31-i-99, note 200a; 6-ii-99, note 206; 24-i-99, note 187; 20-iii-99, note 206, cell 3; 27-ii-99, note 206, cell 2), one ♂, 28.22S 153.05E, Brindle Ck., NSW, Border Ras NP, 14-ii-84, I. D. Naumann, ex ethanol, all in ANIC.

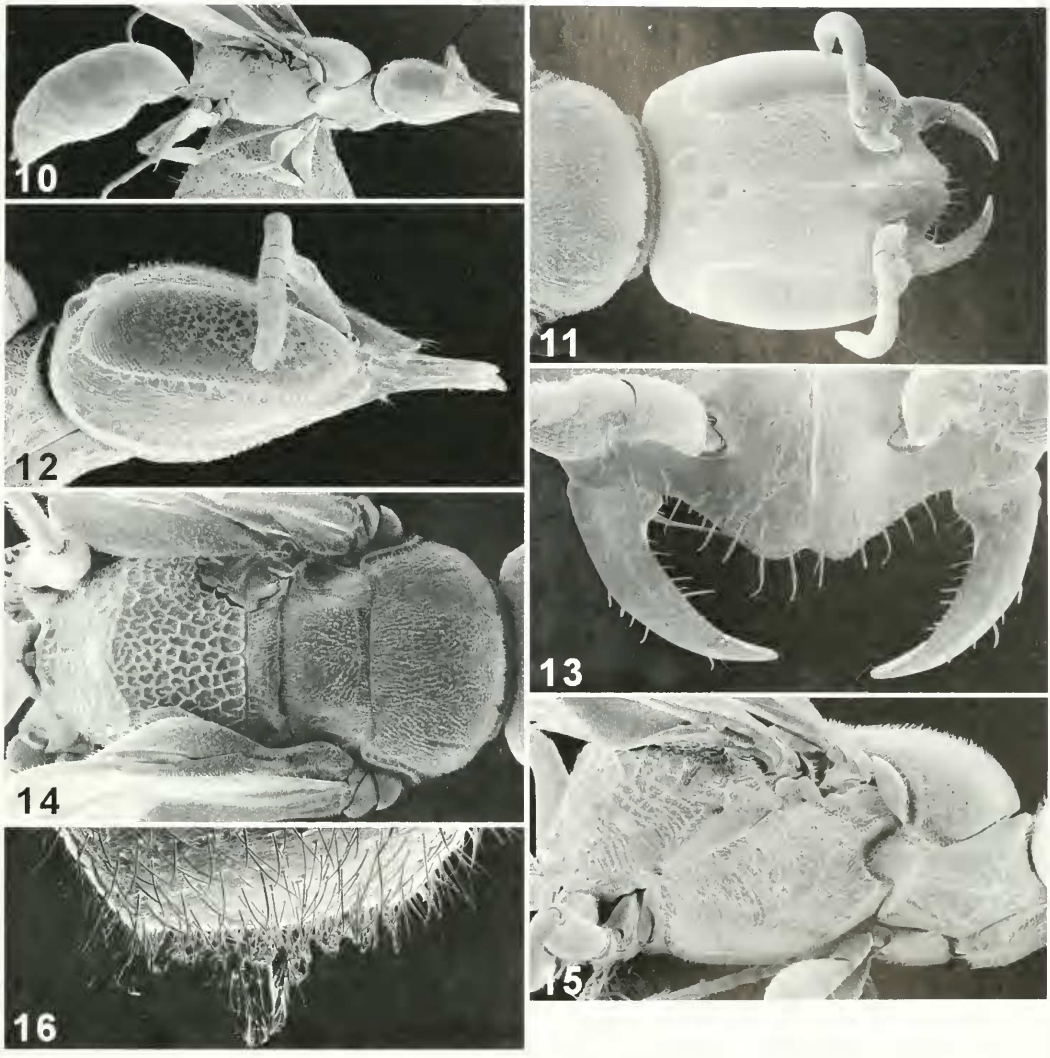


Figs. 4–9. *Arpactophilus*. 4, *A. deserticolus*, head of holotype, dorsal view (48×). 5, *A. arator*, face of holotype showing spinose projection above clypeus (72×). 6, *A. deserticolus*, mesosoma of holotype, dorsal view (44×). 7, *A. kohlii*, mesoscutellum and propodeum of holotype, dorsal view (54×). 8, *A. mimi*, lower face and mandibles (100×). 9, *A. reticulatus*, mesosoma dorsal view (130×).

Female.—Measurements and ratios as in Table 1. *Head:* Globular, without long post-ocellar area. Vertex and face uniformly moderately punctate (Fig. 11), interspaces finely microreticulate. Occipital carina strong laterally, evanescent dorsally. Gena (Fig. 12) microreticulate, becoming strigose to crenulate along genal carina. Genal carina present, but fading ventrally before reaching mandibular sockets. Antennal scrobes well defined, microreticulate to faintly transversely costulate. Frontal carina fine, low and distinct, extending from median ocellus onto about 2/3 length of clypeus (Fig. 11). Circumocular groove narrow and weakly crenulate along inner orbits, becoming crenulate along outer orbits. Clypeus finely micro-

Table 1. Measurement data for nine new *Arpactophilus* species holotypes. (Note: Other than body and wing length, ratios only should be used for comparisons, as measurement units differed across species.) Explanation of abbreviations: BL = length of body (excluding antennae); FWL = length of forewing (apex to tegula); HH = maximum height of head (from vertex to clypeal free margin); HL = maximum length of head (measured at right angles to HH); HW = maximum width of head; UFW = distance between compound eyes measured at level of anterior ocellus; LFW = distance between compound eyes measured just below antennal sockets; POL = minimum distance between lateral ocelli; OOL = minimum distance between lateral ocellus and compound eye; VOL = longitudinal distance between lateral ocelli and back of head (as seen in vertical view); OD = maximum diameter of lateral ocellus; SL = scape length; SW = scape width; FIL = length of first flagellomere; F1W = width of first flagellomere; PL = pedicel length; MSW = maximum width of mesoscutum; MSL = length of mesoscutum (as seen in vertical view).

	hursti sp. nov	*transversum* sp. nov	*ternes* sp. nov	*kakaduensis* sp. nov	*magneticus* sp. nov	*flavifrons* sp. nov.	*similus* sp. nov.	*platycephalus* sp. nov.	*deakinus* sp. nov
BL (mm)	5.0	5.1	4.1	3.2	3.0	3.5	4.4	4.4	4.6
FWL (mm)	3.0	2.7	2.1	2.1	2.1	2.3	2.6	2.5	3.5
HH	28	33	25	18	19	22	27	26	35
HL	17	20	15	13.5	12	13	5	5	19
HW	37	30	30	20.5	19	25	28	27	34
UFW	20	11.5	13	9	8	11	15	15	19
LFW	25	21	14	12	9	14	19	17	19
POL	4	1.5	3.5	2	2	2.5	4	4	4
OOL	5.5	2.5	3	1.5	2	3	4.5	5	5
VOL	6	10	7	4	5	6	2	2	15
OD	3	2	2	1.5	1.5	1.5	1.5	1.5	3
SL	10	12	10	7	7	8	6.5	7	9
SW	3	3	3	2	2	2	2.5	2	3
FIL	6	7	4	2	2	5	3.5	3	4
F1W	4	5	3.5	2	2	2.5	3	3	3
PL	5	6	5	5	5	6	5	5	8
MSW	30	27	25	17.5	16	19	23	19	29
MSL	20	18	16	12	11	12	13	13	21



Figs. 10–16. *Arpactophilus deakinus*, paratype female. 10, Body, lateral (36×). 11–12, Head, frontal (66×) and lateral (110×). 13, Lower face, clypeal margin and mandibles (160×). 14–15, Mesosoma, dorsal (66×) and lateral (94×). 16, Dorsal view of apex of tergum 6 (220×).

reticulate, narrowly emarginate apically (Fig. 13). Labrum with four uniformly spaced teeth, the outer ones slightly smaller and more pointed. Mandible evenly curved, bidentate apically, the outer tooth about twice as long as inner tooth. *Antenna:* Scape and flagellomeres stout; first flagellomere nearly half as long as pedicel and only slightly longer than wide. Scapal length equal to pedicel plus first 3 flagellomeres. *Mesosoma:* Pronotal carina a low keel (Figs. 11,12, and 15), distinctly separated from anterior margin of mesoscutum by about width of first flagellomere at its narrowest point, curving slightly anteriorly laterally, but lacking angulate anterolateral margin, posteriorly longitudinally striate, most apparent laterally. Mesoscutum (Fig.14) convex, uniformly covered with fine, closely spaced setigerous punctures, interspaces finely microreticulate; parapsidal lines distinct, well de-

fined; notauli evident at anterior margins, but less distinct than parapsidal lines. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutellar sulcus narrow. Mesopleuron (Fig. 15) posteriorly obliquely costulate/coriaceous; hypersternaulus distinct, crenulate, narrow, broadening posteriorly; omaulus present, acetabular carina absent; metapleuron clothed with short hairs, obscuring microsculpture. Propodeum uniformly areolate rugose (Fig. 14); posterior face transversely strigose costulate with a small central dorsal smooth area bounded by a Y-shaped carina whose base extends to metasomal insertion. *Forewing:* Second submarginal cell narrowed anteriorly, trapezoidal; first recurrent vein received by submarginal I; M beyond 2r-m absent. *Metasoma:* Terga 1 and 2 smooth, shining, with widely scattered setigerous punctures. T2–5 uniformly faintly microreticulate. T6 apically truncate with dense brush of short setae (Fig. 16). *Color:* Head, mesosoma, and metasoma black, non-metallic. Antenna, mouthparts, tegula, legs (except coxae) orange/red. Coxae black basally, suffused with red/orange distally. Forewing hyaline, venation yellow over basal half; stigma and distal veins brown.

Male.—Identical to female in size, sculpture, and color. Paramere broad, apically blunt, glabrous except for short setae over apical area. Aedeagus strongly curved and pointed apically, nearly as long as paramere. Cuspis triangular, flattened, about half length of paramere, with a slight twist along longitudinal axis. Digitus about 0.85× cuspis, slightly swollen and setose apically.

Etymology.—The specific name refers to the Canberra suburb where the type specimen was collected, and is a noun in apposition.

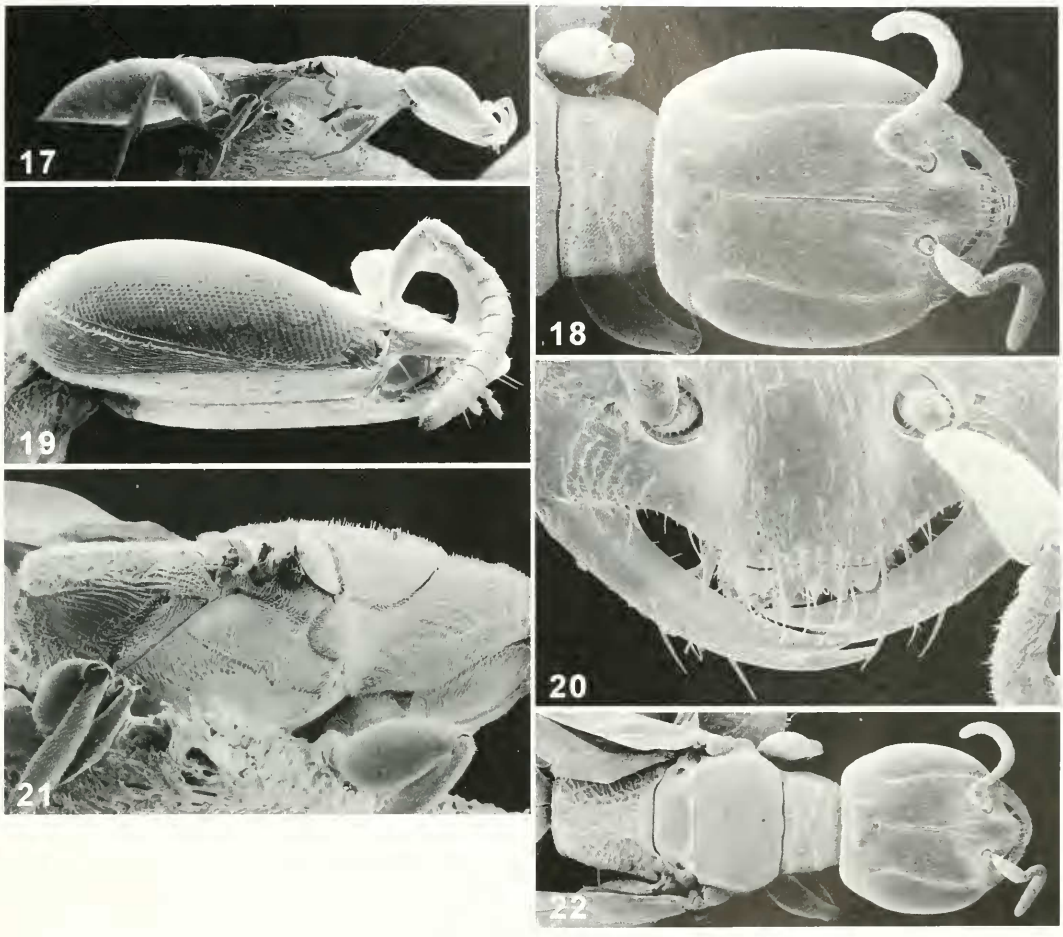
Diagnosis.—This species appears to be most similar to *A. glabrellus* (Turner) known only from W. Australia. It differs in being larger and entirely black (*A. glabrellus* mesosoma and metasoma are a deep mahogany brown). The second submarginal cell is more trapezoidal in *A. deakinus*, with the second abscissa of Rs + M about equal to anterior veinlet of submarginal II, whereas it is distinctly shorter in *A. glabrellus*. Finally, *A. deakinus* has a much more extensively sculptured propodeal hindface, which is nearly smooth and glabrous in *A. glabrellus*, and a much more uniformly punctate mesopleuron than does *A. glabrellus*.

Arpactophilus platycephalus Matthews and Naumann, sp. nov.

(Figs. 17–22; Table 1)

Type material.—Holotype ♀, 19.09S 146.52E, Arcadia Magnetic Is. QLD, 27-xi-98, R. W. Matthews, Reared ex gall of *Sphaleractis* sp. on *Persoonia falcata*, Note 114, cell 2, in ANIC. Paratypes: 3 ♀♀, all same locality as holotype (dates and notes are 8-xi-98, note 115; 27-xi-98, note 115, cell 1; 8-xi-98, note 114); one ♀ Jim Jim Creek, 19km WSW of Mt. Cahill, N.T., 24-x-72, D. H. Colless. One paratype in Queensland Museum; others in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Strongly flattened, elongate, almost prognathous. Vertex and face uniformly faintly microreticulate (Fig. 18). Occipital carina strong laterally, joining hypostomal carina ventrally, absent dorsally. Hypostoma with scattered fine setigerous punctures, interspaces microreticulate. Gena (Fig. 19) very narrow, faintly microreticulate, genal carina barely evident. Antennal scrobes shallow, indistinct, sculpture continuous with face. Frontal carina fine, low and distinct, not extending onto clypeus, flanked by very fine short carinae on either side at level of antennal sockets. Circumocular groove absent. Postocellar area very short, less than half distance between lateral ocelli, and broadly concave posteriorly in dorsal view. Clypeus flattened, medially shining to very faintly microreticulate apically and laterally, broadly emarginate apically (Fig. 20). Labrum with six uniformly spaced teeth.



Figs. 17–22. *Arpactophilus platycephalus*, paratype female. 17, Body, lateral (26×). 18–19, Head, frontal (110×) and lateral (100×). 20, Lower face, clypeal margin, labrum, and mandibles (300×). 21, Mesosoma, lateral (86×). 22, Head and mesosoma, dorsal (60×).

Mandible evenly curved, bidentate apically, the outer tooth distinctly longer than inner tooth. *Antenna:* Scape and flagellomeres slender; first flagellomere slightly longer than half of pedicel and about as long as wide. Scape short, not quite reaching mid orbit, length equal to pedicel plus first 2 flagellomeres. *Mesosoma:* Pronotum elongate, flattened, much narrower than head and mesoscutum. Pronotal carina crossing at about half of pronotal length, slightly raised, forming a "v" medially as seen in dorsal view (Figs. 18, 22), lateral and dorsal portions posterior to carina weakly longitudinally striate, faintly transversely strigose anterior to carina medially. Mesoscutum (Figs. 21, 22) extremely flattened, uniformly finely microreticulate, becoming very faintly longitudinally striate along posterior margin; parapsidal lines and notauli absent. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutellar sulcus narrow and crenulate. Mesopleuron (Fig. 21) with episternal sulcus curving posteriorly to become continuous with hypersternaulus as a rather broad crenulate furrow; acetabular carina absent. Propodeum areolate rugose, interspaces faintly microreticulate, the dorsal face with 4 somewhat

more pronounced oblique longitudinal carinae, two lateral, two more medial, converging posteriorly (Fig. 22); posterior face short, about half as long as dorsal face, with a medial carina extending ventrally from a small shining triangular area, otherwise microreticulate with a few weak irregular carinae laterally, and three evenly spaced, barely apparent weak tubercles along posterior lateral margins. *Forewing:* Second submarginal cell narrowed anteriorly, triangular, essentially lacking the anterior veinlet; first recurrent vein received by submarginal I; second abscissa of Rs + M subequal to basal veinlet of submarginal II; M distinctly evident beyond 2r-m. *Metasoma:* Terga 1 and 2 smooth, shining, with widely spaced minute setigerous punctures. T3–5 uniformly faintly microreticulate. T6 smooth, shining, rounded apically, with a dense brush of very short whitish setae along apical margin. S6 with several golden setae that are distinctly longer than any other sternal setae. *Color:* Head, mesosoma, and metasoma black, non-metallic. Antennae, mouthparts, legs (including coxae) orange/red. Forewing hyaline, venation including stigma uniformly straw yellow.

Male.—Unknown.

Etymology.—The specific name is in reference to the distinctive head shape (Fig. 19).

Diagnosis.—This species belongs to a unique group in the genus characterized by the strongly dorsoventrally compressed head and body and elongate prothorax, the latter reminiscent of *Nitela.* Its closest relative appears to be *A. similus* sp. n., from which it differs by having the head entirely black and submarginal II triangular.

Arpactophilus similus Matthews and Naumann, sp. nov.

(Table 1)

Type material.—Holotype ♀, 12.51S 132.48E, Kakadu NP, Northern Territory, Nourlangie Rock, 16-v-99, R. W. Matthews, ex gall of *Sphaeractis* sp. on *Persoonia falcata,* Note 260, in ANIC. Paratypes: 3 ♀♀, all same locality as holotype (dates and notes are 18-v-99, note 254; 22-v-99, note 265; 22-v-99, note 265a). All in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Strongly flattened, almost prognathous. Vertex and face uniformly faintly microreticulate. Occipital carina strong laterally, joining hypostomal carina ventrally, absent dorsally. Hypostoma with widely scattered fine punctures, the interspaces microreticulate; gena faintly microreticulate, genal carina present, fading toward mandibular socket. Antennal scrobes shallow, indistinct, sculpture continuous with face. Frontal carina fine, low and distinct, not extending onto clypeus, flanked by 2–4 very fine short carinae on either side at level of antennal socket. Circumocular groove absent. Postocellar area very short, about half of distance between lateral ocelli, and broadly concave posteriorly in dorsal view. Clypeus flattened, faintly microreticulate, narrowly emarginate apically. Labrum with six uniformly spaced teeth. Mandible evenly curved, bidentate apically, the outer tooth distinctly longer than inner tooth. *Antenna:* Scape and flagellomeres slender; first flagellomere slightly longer than half of pedicel and about as long as wide. Scape short, not quite reaching mid orbit, length equal to pedicel plus first 2 flagellomeres. *Mesosoma:* Pronotum elongate, flattened, much narrower than head and mesoscutum. Pronotal carina crossing at about half of pronotal length, strongly raised, forming a "v" medially as seen in dorsal view; lateral face posterior to carina longitudinally striate; dorsal face posterior to carina rugose changing to longitudinally striate along anterior margin of mesoscutum; central part anterior to "v" slightly swollen, microreticulate. Mesoscutum extremely flattened, uniformly finely microreticulate, lateral margins along tegulae narrowly crenulate; parapsidal lines present, in-

distinct; notauli absent. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutallar sulcus narrow and with 7 evenly spaced carinulae. Mesopleural central area faintly rugose to microreticulate; episternal sulcus curving posteriorly to become continuous with hypersternaulus as a relatively deep furrow; acetabular carina absent. Propodeum areolate rugose, the interspaces faintly microreticulate, the dorsal face with 4 somewhat more pronounced oblique longitudinal carinae, two lateral, two more medial, converging posteriorly; posterior face short, about half as long as dorsal face, with a medial longitudinal carina arising at propodeal insertion, forking to form a "y" dorsally, the two arms of the fork forming the posterior margin of the dorsal face and curving around to form a slight tubercle on each lateral margin, otherwise microreticulate above to rugulose below. *Forewing:* Second submarginal cell slightly narrowed anteriorly, trapezoidal, the anterior veinlet slightly longer than the second abscissa of Rs + M; first recurrent vein received well into submarginal I; M barely evident beyond 2r-m. *Metasoma:* Terga 1–6 uniformly faintly microreticulate. T6 rounded apically with a dense brush of very short whitish setae along apical margin. S6 with several golden setae distinctly longer than any other sternal setae. *Color:* Body black, non-metallic, except clypeus below antennal sockets orange/red. Antennae, mouthparts, legs (including coxae), and pronotal lobes orange/red. Forewing hyaline; venation including stigma uniformly straw yellow.

Male.—Unknown.

Etymology.—The specific name is in reference to the close similarity to *A. platycephalus.*

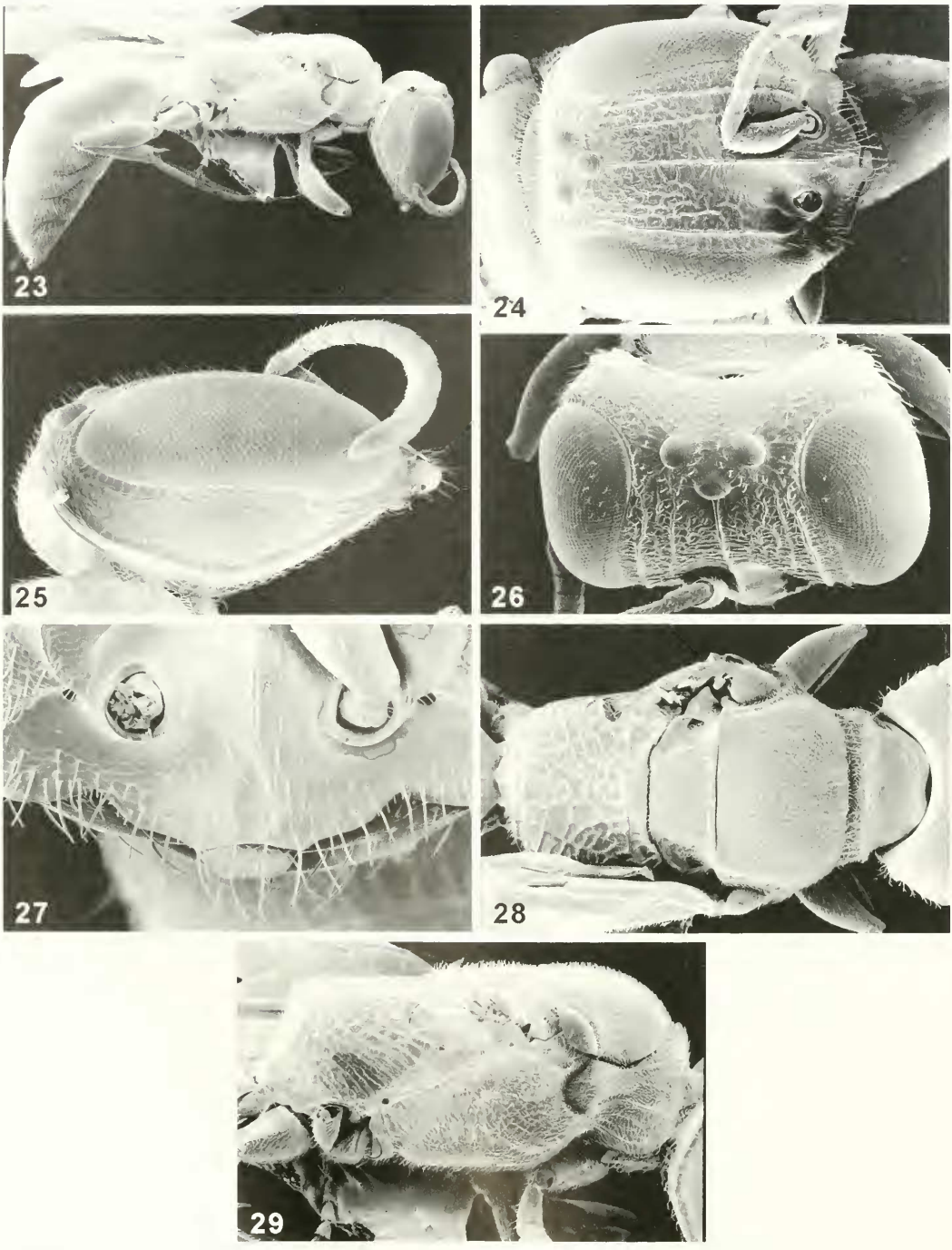
Diagnosis.—This species seems closely related to *A. platycephalus.* It is most readily distinguished by the orange/red clypeus and the trapezoidal shape of the second submarginal cell.

Arpactophilus flavifrons Matthews and Naumann, sp. nov.

(Figs. 23–29; Table 1)

Type material.—Holotype ♀, 19.09S 146.52E, Arcadia Magnetic Is. QLD, 8-xi-98, R. W. Matthews, reared ex burrow in *Lophostemon grandiflorus,* Note 90, in ANIC. Paratypes: 2 ♀♀, 1 ♂, all same locality as holotype (dates and notes are: 28-x-98, reared ex burrow in *Lophostemon grandiflorus,* Note 90; 8-xi-98, ex bamboo; 14-xii-98, ex bamboo, Note 182), one paratype in Queensland Museum, remainder in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Globular. Face irregularly longitudinally strigose confused reticulate (Fig. 24), with a well-defined but irregular longitudinal carina flanking eye inner orbit. Frontal carina straight, low and distinct, extending from median ocellus to mid clypeus where it forks, the branches nearly reaching clypeal free margin. Vertex (Fig. 26) becoming faintly transversely strigose posteriorly. Occipital carina strong laterally, evanescent dorsally. Gena (Fig. 25) microreticulate; genal carina well developed, crenulate. Antennal scrobes well defined, microreticulate. Circumocular groove narrow and weakly crenulate along outer orbits, disappearing at inner orbits. Clypeus finely microreticulate, apically nearly truncate (Fig. 27). Labrum broad, truncate apically, lacking teeth. Mandible slender, evenly curved, bidentate apically, the outer tooth about twice as long as inner tooth. Eyes with scattered short hairs (Figs. 24–26). *Antenna:* Flagellomeres slender relative to scape; first flagellomere nearly as long as pedicel and twice as long as wide. Scapal length equal to pedicel plus first 2 flagellomeres. *Mesosoma:* Pronotal carina raised (Figs. 28–29), distinctly separated from anterior margin of mesoscutum by about width of first flagellomere, anterolateral margin rounded, not strongly angulate, space between carina and anterior margin of me-



Figs. 23–29. *Arpactophilus flavifrons*, paratype female. 23, Body, lateral (48×). 24–26, Head, frontal (120×), lateral (130×), and dorsal (120×). 27, Lower face, clypeal margin, and labrum (320×). 28–29, Mesosoma, dorsal (110×) and lateral (100×).

soscutum longitudinally striate. Mesoscutum (Fig. 28) convex, uniformly covered with fine setigerous punctures, except lateral margin along tegula crenulate; parapsidal lines present, somewhat indistinct; notauli well defined. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutellar sulcus narrow and with a well defined median carina. Mesopleuron (Fig. 29) irregularly weakly strigose; hypersternaulus indistinct, a shallow depression broadening posteriorly, and weakly crenulate; acetabular carina absent. Propodeum uniformly areolate rugose (Fig. 28); lateral face longitudinally strigose anteriorly, becoming areolate rugose dorsally; posterior face transversely strigose on either side of a median y-shaped carina whose base extends to metasomal insertion. *Forewing:* Second submarginal cell narrowed anteriorly, trapezoidal; first recurrent vein inserting on first submarginal cell; second abscissa of Rs + M slightly longer than anterior veinlet of second submarginal cell; M barely evident beyond 2r-m. *Metasoma:* Tergites smooth, shining, very faint microreticulation laterally on T3–6. T6 apically rounded with dense brush of short setae. *Color:* Head black except yellow clypeus and around mandibular sockets, extending slightly onto gena and along lower inner orbit. Mesosoma black, except pronotal lobe and anterior margin of pronotum cream. Metasoma red/orange, except ovipositor sheaths brown. Scape and mouthparts yellow, flagellum brown. Legs (including coxae) yellow. Forewing hyaline, veins and stigma light brown.

Male.—Identical to ♀ in size, sculpture, and color, except that yellow on head is more extensive, reaching to just beyond middle of orbit on both gena and frons and entire hypostomal area. Pedicel and first two flagellomeres are orange/red, remainder of flagellum becoming dark brown. Tarsomere 5 light brown. Genitalia not studied.

Etymology.—The specific name refers to the extensive yellow on the male's face.

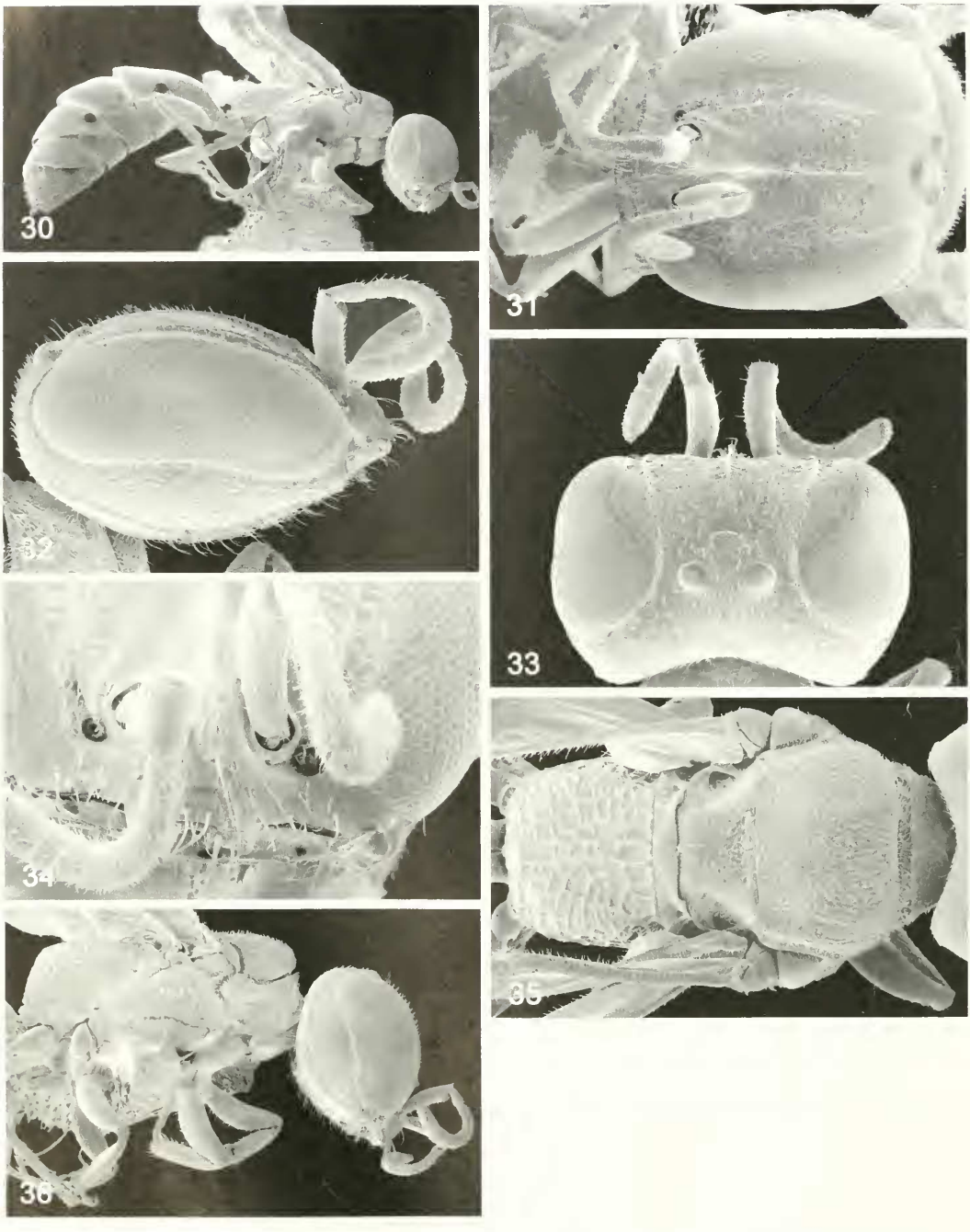
Diagnosis.—The truncate toothless labrum is distinctive, as is the color pattern on the head, the presence of the adorbital carina, and the forked frontal carina. *Arpactophilus tricolor* has somewhat similar facial coloration, but more extensive yellow in the female (male unknown). In *A. tricolor* the metasoma is black, whereas it is red in *A. flavifrons*. *Arpactophilus magneticus* is superficially similar with well-defined adorbital carinae, and it nests in the same place. However, the form of the labrum, frontal carina, and pronotal carina differ markedly, and the head is entirely black.

Arpactophilus magneticus Matthews and Naumann, sp. nov.

(Figs. 30–36; Table 1)

Type material.—Holotype ♀, 19.09S 146.52E, Arcadia Magnetic Is. QLD, 28-x-98, R. W. Matthews, reared ex burrow in *Lophostemon grandiflorus*, Note 85, in ANIC. Paratypes: 9 ♀♀, 2 ♂♂, all same locality as holotype (dates and notes are: 13-x-98, 16-xi-98, reared ex burrow in *Mallotus phillipensis*, Note 2; 15-x-98, 26-x-98, ex burrow in *Lophostemon grandiflorus*, Note 76; 24-x-98, ex burrow in *Lophostemon grandiflorus*, Note 85; 3-xii-98, ex burrow in *Neolitsia australiensis*, Note 170; 6-xii-98, ex burrow in *Mallotus phillipensis*, Note 172), two paratypes: in Queensland Museum, remainder in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Globular. Face microreticulate becoming weakly transversely wrinkled dorsally, with evenly spaced short erect hairs, and with a well-defined longitudinal carina flanking each inner orbit (Fig. 31). Frontal carina straight, low and distinct, not quite reaching median ocellus and barely extending onto clypeus. Vertex (Fig. 33) becoming faintly transversely strigose posteriorly. Occipital carina strong laterally, evanescent dorsally. Gena (Fig. 32) shining, faintly longitudi-



Figs. 30–36. *Arpactophilus magneticus*, paratype female. 30, Body, lateral (30×). 31–33, Head, frontal (160×), lateral (160×), and dorsal (180×). 34, Lower face, clypeal margin, and mandibles (300×). 35, Mesosoma, dorsal (160×). 35, Mesosoma and head, lateral (86×).

nally strigose; genal carina well developed. Antennal scrobes weakly defined, smooth to faintly microreticulate. Circumocular groove very narrow and indistinct posteriorly, absent anteriorly. Clypeus (Fig. 34) smooth, apically broadly rounded, with scattered elongate setae, twice as long as those on frons. Labrum with 4 evenly spaced short teeth (Fig. 34). Mandible slender, evenly curved, bidentate apically, the outer tooth about twice as long as inner tooth. *Antenna:* Flagellomeres short and stout, more or less quadrate (Fig. 32); first flagellomere nearly half as long as pedicel and as wide as long. Scapal length equal to pedicel plus first 4 flagellomeres. *Mesosoma:* Pronotal carina (Fig. 35) low, not especially raised and barely separated from anterior margin of mesoscutum, anterolateral margin rounded, not at all angulate, laterally the space between carina and anterior margin of mesoscutum longitudinally striate. Pronotal collar anterior to carina microreticulate. Mesoscutum (Fig. 35) convex, uniformly covered with fine setigerous punctures, except lateral margin along tegula crenulate; parapsidal lines present, somewhat indistinct; notauli indistinct. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutellar sulcus narrow with a well-defined median carina. Mesopleuron (Fig. 36) dorsally irregularly wrinkled weak rugose, with fine setigerous punctures, becoming microreticulate centrally; hypersternaulus a weakly crenulate shallow depression broadening posteriorly; acetabular carina absent. Propodeum areolate rugose (Fig. 35); lateral face longitudinally strigose anteriorly, the interspaces microreticulate, becoming areolate rugose dorsally; posterior face transversely strigose on either side of a median longitudinal carina. *Forewing:* Second submarginal cell broad anteriorly, nearly quadrate; first recurrent vein inserting on the very end of first submarginal cell, essentially interstitial; M barely evident beyond 2r-m. *Metasoma:* Terga smooth, shining, very faint microreticulation laterally on T3–6. *Color:* Head and mesosoma black. Metasoma red/orange. Antenna, mouthparts, and legs (including coxae) red/orange. Forewing hyaline, veins and stigma light brown.

Male.—Similar to female in size, sculpture, and color, except lower two-thirds of face clothed with dense silvery pubescence and adorbital carina absent. Eyes more strongly convergent above, the ratio of LFW:UFW 12:7. Fore and middle legs, mouthparts and antenna yellow, the last flagellomere brown. Genitalia not studied.

Etymology.—The specific name is in reference to the type locality, Magnetic Island, Queensland.

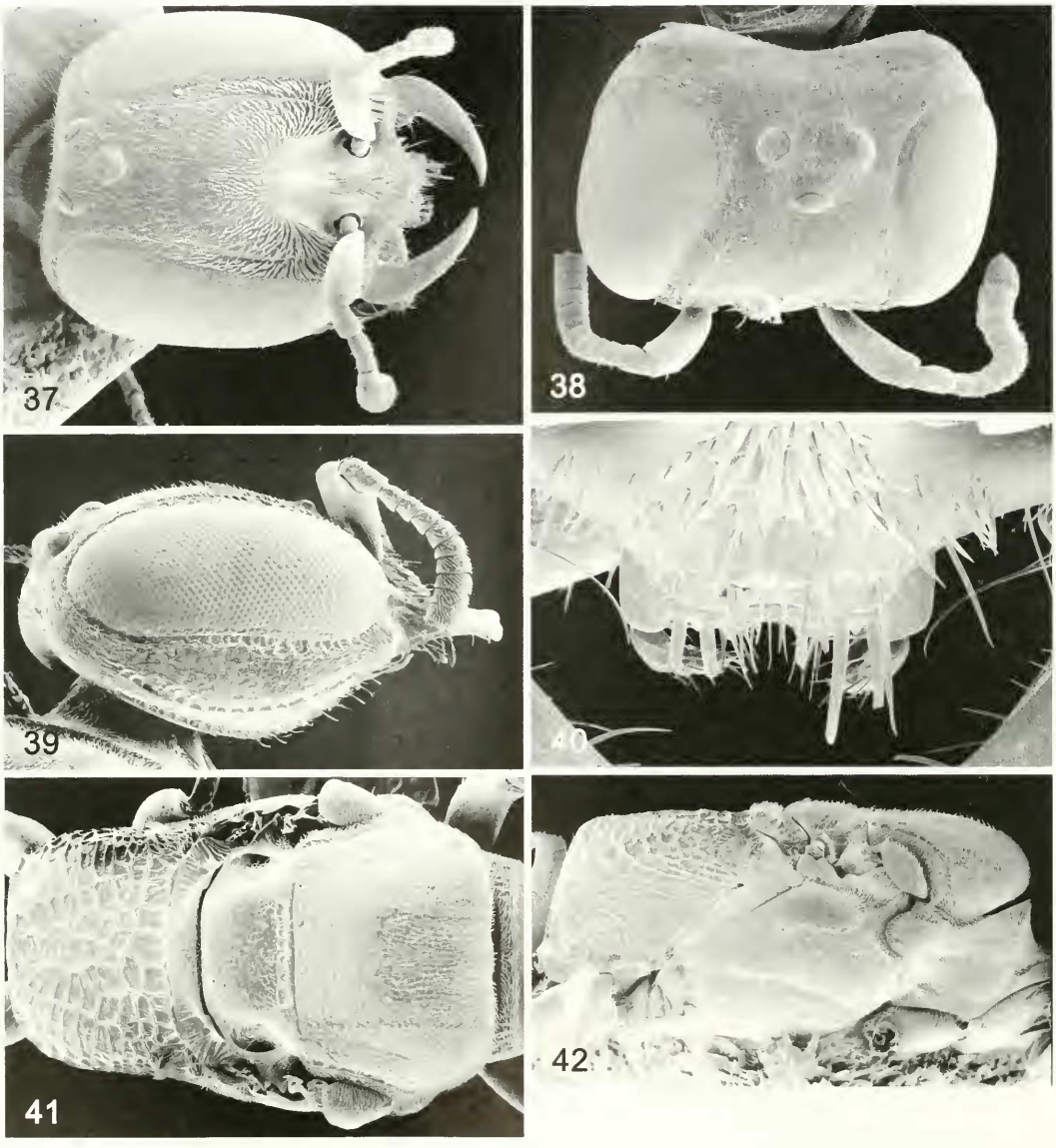
Diagnosis.—This species is superficially similar to *A. flavifrons* and nests in the same habitat, but differs in several important respects, notably the lack of yellow on the lower face and the forewing venation. Additionally, the presence of silver facial pubescence in the male face is unusual as this occurs only rarely in other species (e.g., *A. kakaduensis*) where the male is known.

Distribution.—In addition to the type locality, specimens in the ANIC have been taken at Mt. Spec, Qld., Gordonvale, Qld., Bald Knob State Forest, NSW, and Otford, NSW.

Arpactophilus kakaduensis Matthews and Naumann, sp. nov.

(Figs 37–41; Table 1)

Type material.—Holotype ♀, 12.51S 132.48E, Kakadu NP, Northern Territory, Nourlangie Rock, 16-v-99, R. W. Matthews, ex gall of *Sphaleractis* sp. on *Persoonia falcata,* Note 244, in ANIC. Paratypes: 38 ♀♀, 12 ♂♂, all same locality as holotype (dates and notes are: 16-v-99, note 244, two ♀♀, one ♂; 16-v-99, note 243a, one ♀; 16-v-99, note 243b, one ♀, one ♂; 17-v-99, note 246a, one ♀; 17-v-99, note 246b, one ♀; 17-v-99, note 247, two ♀♀, one ♂; 18-v-99, note 256, 5 ♀♀; 22-v-99, note 266 unassociated with nests, 20



Figs. 37–42. *Arpactophilus kakaduensis*, paratype female. 37–39, Head, frontal (120×), dorsal (160×), and lateral (150×). 40, Clypeal margin and labrum (540×). 41–42, Mesosoma, dorsal (150×) and lateral (94×).

♀♀, 5 ♂♂; 22-v-99, note 266a, two ♀♀; 22-v-99, note 266b, one ♀, one ♂; 22-v-99, note 266c, one ♂; 22-v-99, note 266d, one ♀; 22-v-99, note 266e, one ♀; 22-v-99, note 266g, one ♂; 22-v-99, note 266h, one ♂), all in ANIC, except two in Queensland Museum.

Female.—Measurements and ratios as in Table 1. *Head:* Globular. Face uniformly covered with fine setigerous punctures (Figs. 37–38), the setae short and erect. Frontal carina straight, low and indistinct, extending from below median ocellus barely onto clypeus, section between antennal scrobes slightly raised, lamellate, with very small but distinct tubercle. Vertex (Fig. 38) sparsely finely punctate around ocelli, becoming faintly microreti-

culate posteriorly; distance between lateral ocelli distinctly greater than distance between lateral ocellus and eye; posterior margin of vertex concave in dorsal view. Occipital carina evident laterally, evanescent dorsally. Gena (Fig. 39) somewhat shining, faintly longitudinally strigose to microreticulate; genal carina crenulate, well developed posteriorly, fading toward mandibular socket. Antennal scrobes deep grooves, smooth to faintly microreticulate. Circumocular groove very narrow and crenulate, disappearing at mid face. Clypeus (Figs. 37 and 40) smooth, somewhat convex and apically broadly truncate, with numerous short flattened setae basally. Labrum broad with 6 to 8 closely-spaced short teeth, and with 6 short stiff apical setae (Fig.40). Mandible slender, evenly curved, bidentate apically, the outer tooth only slightly longer than inner. *Antenna:* Flagellomeres short and stout, more or less quadrate (Figs. 38–39); first flagellomere nearly half as long as pedicel and as wide as long. Scapal length equal to pedicel plus first 4 flagellomeres. Last flagellomere slightly flattened distally. *Mesosoma:* Pronotal carina (Figs. 41–42) low, not at all raised and barely separated from anterior margin of mesoscutum, anterolateral margin rounded. Pronotal collar anterior to carina microreticulate to faintly longitudinally strigose. Mesoscutum (Fig. 41) convex, uniformly covered with fine setigerous punctures, except lateral margin along tegula crenulate; parapsidal lines present, notauli indistinct. Sculpture of mesoscutellum and metanotum essentially same as mesonotum; prescutellar sulcus narrow with a well-defined median carina. Mesopleuron (Fig. 42) smooth to faintly punctate and clothed with short setae; hypersternaulus a narrow crenulate furrow, deepest anteriorly, continuous with episternal sulcus and ending before mid coxa; acetabular carina absent. Propodeum areolate rugose (Fig. 41), with four somewhat more prominent longitudinal carinae converging posteriorly; lateral face finely longitudinally reticulate striate, becoming areolate rugose dorsally; posterior face irregularly weakly reticulate rugose, framed by more prominent carinae along posterolateral and dorsal margins. *Forewing:* Second submarginal cell slightly narrowed anteriorly, approaching trapezoidal shape; first recurrent vein received at the end of submarginal I, second abscissa of Rs + M about one-fourth as long as the anterior veinlet of submarginal II. Vein M distinct, but barely evident beyond 1r-m. *Metasoma:* Terga smooth, shining, very faint microreticulation laterally on T3–6. T6 with well developed transverse brush of dense setae apically. *Color:* Head black except apical half of clypeus and area immediately surrounding mandibular socket cream yellow. Mesosoma predominantly red/orange, except pronotal collar anterior to carina black, and pronotal lobe cream yellow. Metasoma red/orange, the ovipositor sheaths black. Scape and mandibular base cream yellow, flagellae red/orange. Fore and middle legs light yellow; hind legs more red/orange. Forewing hyaline, veins and stigma light brown.

Male.—Similar to female in size, sculpture, and color, except most of face below median ocellus clothed with dense silvery pubescence. Eyes more strongly convergent above, the ratio of LFW:UFW 14:9. Genitalia not studied.

Etymology.—The specific name is in reference to the type locality, Kakadu National Park, Northern Territory.

Diagnosis.—The mesosomal coloration is distinctive, being predominantly red/orange with the anterior portion of the pronotum black. There are several unnamed species in ANIC with the mesosoma predominantly red/orange, with some areas black, but *A. kakaduensis* is the only one to have extensive black restricted to the pronotum. *Arpactophilus ruficollis* has the pronotum red and the mesonotum black. Additionally, the silver pubescence on the

male face of *A. kakaduensis* is distinctive, similar to that of *A. magneticus*.

Arpactophilus transversus Matthews and Naumann, sp. nov.

(Figs 43–50; Table 1)

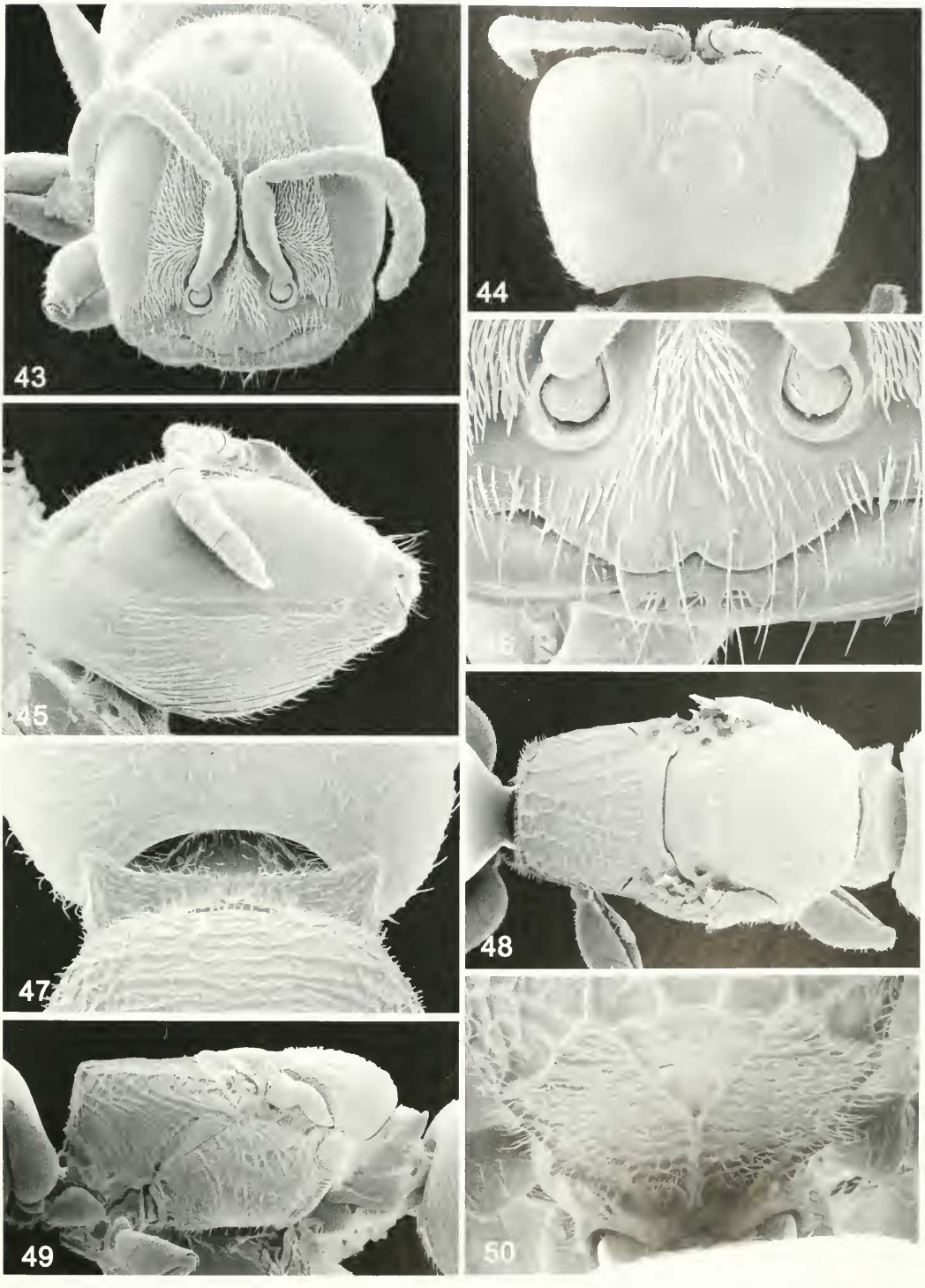
Type material.—Holotype ♀, 12.25S 132.57E, Obiri Rock, Kakadu NP, N. Territory, 21-xi-1979, I. D. Naumann, in ANIC. Paratypes: 2 ♀♀, same data as holotype, one ♀ N. Territory, Kakadu NP, L. Nourlangie Rock, 6-11-vi-1984, R. W. Matthews, all in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Elongate, eyes strongly convergent dorsally. Face longitudinally striate (Fig. 43), lower two-thirds clothed with dense short silver gray setae. Frontal carina distinct, section between antennal scrobes slightly raised, lamellate, fading as it reaches clypeus. Postocellar area long (Fig. 44), VOL about 4× greater than OOL, microreticulate, grading to transversely microreticulate posteriorly; distance between lateral ocelli distinctly less than distance between lateral ocellus and eye. Occipital carina incomplete dorsally. Gena (Fig. 45) longitudinally striate; genal carina absent. Antennal scrobes deep grooves, transversely finely striate. Circumocular groove present along outer orbit, disappearing dorsally, then reappearing along the upper third of inner orbit. Clypeus (Fig. 46) broadly rounded apically and notched medially. Labrum with four evenly spaced teeth, lateral ones slightly broader and more rounded than medial ones. Mandible slender, evenly curved, bidentate apically, outer tooth only slightly longer than inner. *Antenna:* First flagellomere distinctly longer than pedicel (Fig. 43). Length of scape equal to pedicel plus first 4 flagellomeres. *Mesosoma:* Pronotal carina (Figs. 47–48) strongly raised, well separated from anterior margin of mesoscutum, lateral portion slightly curved anteriorly; anterolateral margin erect, sharply angulate. Mesoscutum (Fig. 48) convex, transversely coarsely strigose, lateral margins crenulate; parapsidal lines distinct short grooves, notauli present but indistinct. Mesoscutellum and metanotum nearly smooth to sparsely punctate, interspaces microreticulate. Prescutellar sulcus with 5 evenly spaced longitudinal carinae. Mesopleuron (Fig. 49) irregularly obliquely strigose, hypoepimeral area broadly excavated with 4 oblique carinae; hypersternaulus continuous with episternaulus, forming a broad deep areolate furrow whose sculpture is continuous with surrounding area; acetabular carina present. Propodeum areolate rugose (Fig.48); lateral face obliquely striate; posterior face (Fig. 50) with inverted triangular smooth area medio-dorsally, remainder irregularly transversely rugulose. *Forewing.* Second submarginal cell strongly narrowed anteriorly, nearly triangular; first recurrent vein received by submarginal I, second abscissa of Rs + M about equal to anterior veinlet of submarginal II. Vein M absent beyond 2r-m. *Metasoma:* T1 with sparse small setigerous punctures, except on basal half, otherwise shining, smooth; T2 covered with similar punctures over otherwise smooth, shining distal two-thirds, basal one-third uniformly microreticulate expanding to include most of lateral area; T3–6 microreticulate, strongest on T3. T6 more or less smooth,with scattered distinct punctures, a brush of short setae at apex. S6 with a row of 4 distinctly longer, erect setae on either side of midline towards apex. *Color:* Body black except pronotal lobes lighter brown yellow. Scape and mandible (except teeth) yellow, flagellum red/orange. Legs yellow, except coxae somewhat more orange. Forewing hyaline, veins and stigma very light brown.

Male.—Unknown.

Etymology.—The specific name refers to the transverse sculpture of mesoscutum.

Diagnosis.—In general facies this species resembles *A. termes*, and nests in a similar habitat. It differs in the more elongate head shape behind the orbits, the strongly



Figs. 43–50. *Arpactophilus transversus*, paratype female. 43–45, Head, frontal (54×), dorsal (72×), and lateral (60×). 46, Lower face, clypeal margin, and labrum (240×). 47, Pronotum, dorsal (72×). 48–49, Mesosoma, dorsal (48×) and lateral (48×). 50, Propodeum, posterior face (150×).

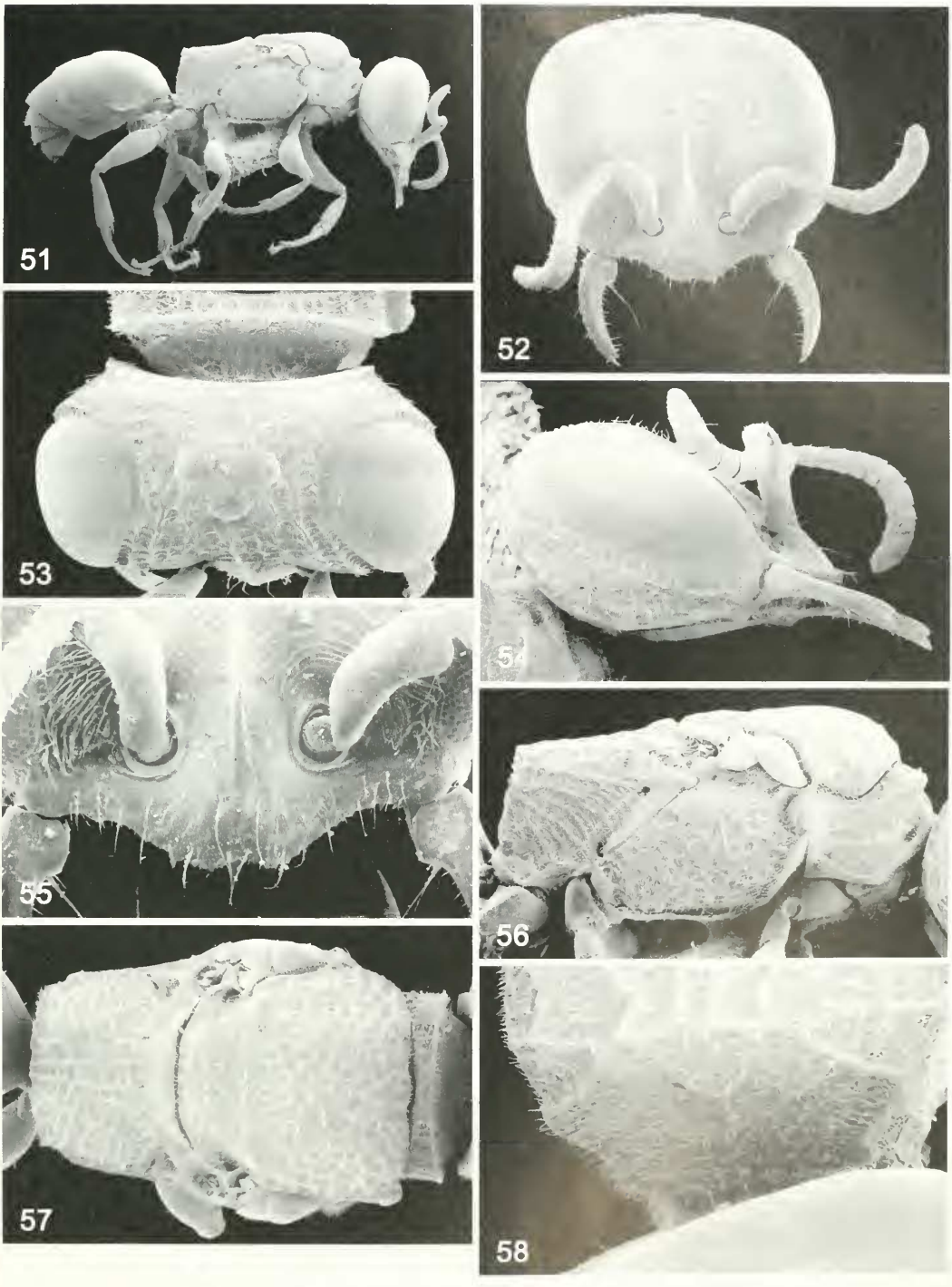
convergent eyes dorsally, striate gena, and transversely strigose mesonotum. It is the only species known to us to have predominantly transversely oriented mesoscutal sculpturing.The dense silver gray facial pubescence in females is also distinctive. This species was referred to as *Arpactophilus* sp. 48 in Naumann (1983).

Arpactophilus termes Matthews and Naumann, sp. nov.

(Figs. 51–58; Table 1)

Type material.—Holotype ♀, 12.51S 132.48E, Kakadu NP, Northern Territory, Nourlangie Rock, 17-v-99, R. W. Matthews, ex old termite gallery, Note 245, in ANIC. Paratypes: 13 ♀♀, 5 ♂♂, all same data as holotype, all in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Globular. Face rugose reticulate (Fig. 52), interspaces finely microreticulate, with more predominant longitudinal lateral carina more or less parallel to circumocular groove. Frontal carina distinct, section between antennal scrobes slightly raised, lamellate, fading as it reaches clypeus.Vertex (Fig. 53) coarsely rugose reticulate grading to transversely microreticulate posteriorly; distance between lateral ocelli subequal to distance between lateral ocellus and eye. Occipital carina complete, somewhat weaker dorsally. Gena (Fig. 54) irrigularly strigose reticulate along carina, the interspaces microreticulate, becoming predominantly microreticulate along circumocular groove; genal carina welldeveloped distinctly crenulate, fading toward mandibular socket. Antennal scrobes deep grooves, transversely striate. Circumocular groove complete, well defined, deep, and crenulate. Clypeus (Fig. 55) somewhat convex and flattened medially, microreticulate, broadly emarginate apically, the margin serrated. Mandible slender, evenly curved, bidentate apically, the outer tooth only slightly longer than inner. *Antenna:* Flagellomeres short and stout, more or less quadrate (Figs. 52 and 54); first flagellomere subequal to pedicel. Scape length equal to pedicel plus first 4 flagellomeres. *Mesosoma:* Pronotal carina (Figs. 53 and 57) strongly raised, well separated from anterior margin of mesoscutum; anterolateral margin sharply angulate; posterior face deeply costulate. Mesoscutum (Fig. 57) convex, coarsely rugose reticulate, interspaces microreticulate, lateral margin crenulate; parapsidal lines deep short grooves; notauli indistinct. Mesoscutellum and metanotum with several coarse punctures, interspaces microreticulate. Mesopleuron (Fig. 56) irregularly rugose reticulate below microreticulate hypoepimeral area. Hypersternaulus continuous with episternaulus, their coarsely crenulate sculpture intergrading with remainder of mesopleuron; acetabular carina present. Propodeum areolate rugose, the interspaces microreticulate (Fig. 57), with 4 somewhat more prominent longitudinal carinae converging posteriorly; lateral face obliquely striate, interspaces finely microreticulate, becoming areolate rugose dorsally; posterior face (Fig. 58) weakly irregularly reticulate rugose, framed by more prominent carinae along dorsal and lateral margins. *Forewing:* Second submarginal cell strongly narrowed anteriorly, approaching triangular; first recurrent vein received by submarginal I, second abscissa of Rs + M nearly as long as anterior veinlet of submarginal II; vein M absent beyond 2r-m. *Metasoma:* T1 sparsely covered with small setigerous punctures, except on anterior medial area, otherwise shining, smooth; T2 sparsely covered with similar punctures over otherwise smooth, shining distal two-thirds, the basal one-third uniformly microreticulate extending to include most of lateral area; T3–6 uniformly microreticulate, strongest on T3. T6 more or less smooth with scattered distinct punctures, a brush of short setae at apex. *Color:* Body black except pronotal lobes light brown yellow. Scape and mandible (except teeth) yellow, flagellum red/orange. Legs yellow, except



Figs. 51–58. *Arpactophilus termes*, paratype female. 51, Body, lateral (48×). 52–54, Head, frontal (86×), dorsal (150×), and lateral (110×). 55, Lower face, clypeal margin (200×). 56–57. Mesosoma, lateral (86×) and dorsal (110×). 58, Propodeum, posterior face (200×).

fore coxa mostly infused with brown/black. Forewing hyaline, veins and stigma light brown.

Male.—Similar to female in size, sculpture, and color, except that face below median ocellus clothed with dense golden pubescence. Clypeal free margin not serrate and only shallowly emarginate. Pedicel much narrower than first flagellomere; flagellum densely clothed with very short setae. Genitalia not studied.

Etymology.—The specific name refers to nests being found in old termite galleries.

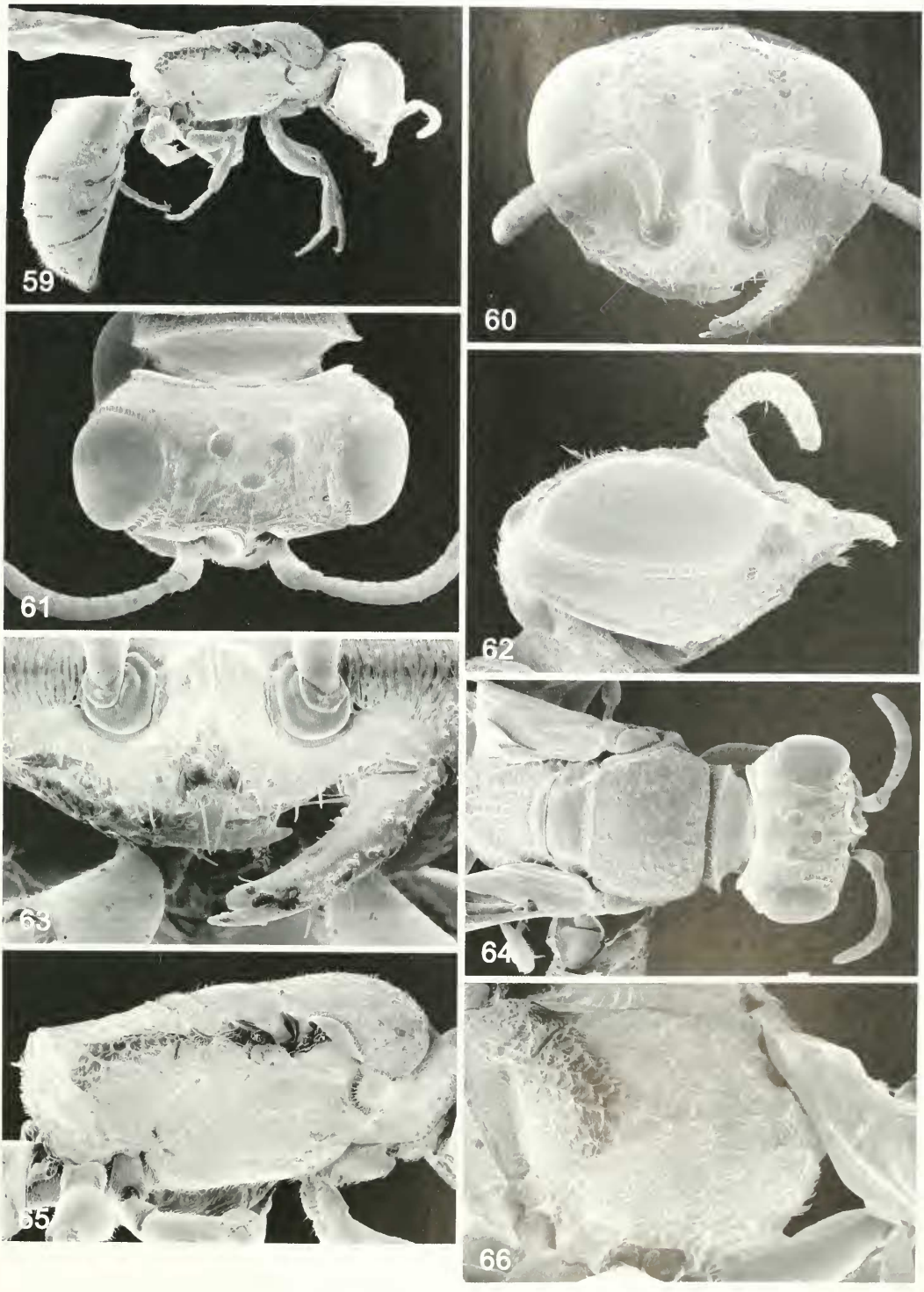
Diagnosis.—The complete occipital carina, complete circumocular groove, rugose reticulate face, presence of the acetabular carina, strongly raised angulate pronotal carina, and serrated emarginate clypeus free margin distinguish this species. It is similar to *A. reticulatus* in the coarse sculpture of head and thorax, but in *A. reticulatus* the pedicel is nearly 2× as long as the first flagellomere, and the clypeal free margin is smooth. Males possess golden facial pubescence similar to that of *A. reticulatus* males.

Arpactophilus hursti Matthews and Naumann, sp. nov.

(Figs 59–66; Table 1)

Type material.—Holotype ♀, Lake Gilles Conservation Park, South Australia, 29-v-1994, Pam Hurst, ex burrow in *Acacia papyrocarpa*, note C-11, in ANIC. Paratypes: 7 ♀♀, 2 ♂♂ all same locality as holotype (dates and notes are 29-v-1994, ex burrow in *Acacia papyrocarpa*, note C-11, 23-vi-1994, ex burrow in *Heterodendron*, 14-vii-1994 in Western Myall, #E-1); one ♀ 25.22S 151.07 E, Eidsvold, Qld., 11-x-1984, I. Naumann, J. Cardale, ex ethanol, all in ANIC.

Female.—Measurements and ratios as in Table 1. *Head:* Globular. Vertex and face irregularly rugose (Figs. 60, 61). Frons lateral to scapes clothed with short dense flattened silvery setae. Occipital carina (Fig. 61) strong laterally, nearly complete dorsally. Gena (Fig. 62) irregularly rugose, lacking a distinct genal carina. Antennal scrobes narrow well-defined grooves, distinctly transversely striate to microreticulate. Frontal carina strongly raised above clypeus between scapes, lamellate, slightly thickened dorsally, and rounded in profile, extending onto about 1/2 length of clypeus. Circumocular groove (Figs. 61, 62) narrow, crenulate, continuous along outer, dorsal, and inner orbits. Clypeus roundly protuberant, apically emarginate (Fig. 63). Labrum with four teeth, outer ones barely evident, inner teeth much longer and somewhat pointed. Mandible evenly curved, bidentate apically, outer tooth about 2× as long as inner tooth, inner tooth relatively broad and blunt apically. *Antenna:* Scape and flagellomeres stout; first flagellomere subequal to pedicel and only slightly longer than wide. Scape length equal to pedicel plus first 4 flagellomeres. *Mesosoma:* Pronotal carina strongly raised, lamellate (Fig. 64), distinctly separated from anterior margin of mesoscutum with sharply angulate anterolateral margin; anterior face shining to transversely microreticulate. Mesoscutum (Fig. 64) convex, irregularly transversely rugulose over anterior third, becoming coarsely punctate on lateral portions, interspaces and central area predominantly microreticulate, finely rugose along posterior portion, lateral margins costulate; parapsidal lines and notauli distinct. Mesoscutellum microreticulate with sparse shallow punctures, prescutellar sulcus narrow with about 10 evenly spaced longitudinal carinae. Metanotum longitudinally strigose. Mesopleuron (Fig. 65) irregularly rugose, becoming obliquely strigose posteriorly, the interspaces microreticulate; hypersternaulus indistinct. Acetabular carina present. Metapleuron clothed with short hairs, obscuring microsculpture. Propodeal dorsum areolate rugose (Fig. 64), lateral face irregularly rugose grading to obliquely strigose, posterior face (Fig. 66) irregularly rugose, lacking tubercles on lateral margins. *Forewing:* Second submarginal cell narrowed anteriorly, nearly



Figs. 59–66. *Arpactophilus hursti*, paratype female. 59, Body, lateral (20×). 60–62, Head, frontal (86×), dorsal (86×), and lateral (55×). 63, Lower face, clypeal margin and mandible (180×). 64, Mesosoma and head, dorsal (54×). 65, Mesosoma, lateral (43×). 66, Propodeum, posterior face (65×).

triangular; first recurrent vein received in submarginal I well proximal to bifurcation of Rs + M by a length distinctly greater than the anterior veinlet of submarginal II; M absent beyond 2r-m. *Metasoma:* Terga 1 and 2 smooth, shining, with widely scattered setigerous punctures. T2–5 uniformly faintly transversely microreticulate with scattered setae. T6 more densely setose, apically truncate with apical brush of short setae. *Color:* Head and mesosoma black, non-metallic, except clypeal margin red/orange. Metasoma, antenna, and legs (except coxae) orange/red. Mandible red/orange over basal third, distally amber brown. Fore coxa black, mid and hind coxa basally black, becoming increasingly suffused with red/orange distally. Forewing hyaline, venation and stigma light brown.

Male.—Identical to female in size, sculpture, and color, except frons (but not clypeus) completely covered with flat golden setae.

Etymology.—This species is named for its collector, Pam Hurst.

Diagnosis.—This species belongs to a group of relatively robust species apparently related to *A. bicolor*, and characterized by having metasoma red/orange and relatively rugose or coarsely punctate sculpture on mesonotum and head. The red/orange clypeal free margin, bladelike, strongly angulate pronotal carina, and absence of hypersternaulus readily separate this species from others in this group.

NOTES ON PREVIOUSLY DESCRIBED SPECIES

Arpactophilus steindachneri Kohl. – Kohl (1884) gives no explicit indication that he based his original description on more than one specimen, but he does give a range ("71/2–8 mm") for the body length. There are two females of *A. steindachneri* in the Naturhistorisches Museum, Wien which bear identical labels except that one bears the word "type" in Kohl's hand writing. A rectangular, red label without data is also affixed to this specimen. Both females agree with Kohl's description and both are within the originally given range for body length. Thus, it seems likely that Kohl had both specimens before him. Accordingly, the specimen labeled "type" by Kohl is hereby designated as lectotype, and the second specimen, as paralectotype.

The type locality given by Kohl (1884) is "Australia". The provenance labels on the type specimens are equally imprecise. However, in the original description, Kohl gives Edward Damel (c. 1821–1900) as the collector. Damel made several collecting trips to Australia between 1852 and 1875, and some of his material was sold widely in Europe through Georg Thorey (1790–1884), a Hamburg insect dealer (Horn et al. 1990, p. 392). The latter explains the appearance of Thorey's name on the provenance labels of the *A. steindachneri* type material. Prior to 1864, Damel collected in Sydney (1852–1858), Western Australia (1859), and at Port Curtis, Queensland (1860) (Musgrave 1932, p. 60). *Arpactophilus steindachneri* has since been collected from several coastal or near coastal localities in north-eastern Australia, but is not known elsewhere. Presumably the type material of *A. steindachneri* was collected during Damel's Port Curtis sojourn which would place the type locality somewhere near present-day Gladstone.

Arpactophilus bicolor Smith.—In the original description of *A. bicolor*, Smith (1864) states, "The male differs in having the scape white in front." The female bearing the type label is thus a syntype.

BIOLOGY

Biological details for each of the nine newly described species plus *A. reticulatus* (Turner) follow. All nests were collected during the day, which means that some associated nest adults were probably absent at the time of collection. Voucher

nests for each species are deposited in the ANIC.

Arpactophilus similus.—Four nests of this flat-headed species were found, all in green, recently vacated galls of *Sphaleractis parasitica* Meyrick (Lepidoptera: Gelichiidae) on the geebung, *Persoonia falcata* (Proteaceae) at Kakadu NP, N.T. on 18–22 May 1999. Each nest contained a single female wasp. This, plus the nest architecture, suggests that this species is strictly solitary. In one nest, the two cells were in linear series in a tunnel whose diameter was 2 mm, and afforded no opportunity for movement between the wall and the cells. Cell one, 3.5 mm long, contained a prepupa, essentially naked with no evident cell lining. The cell partition was a tan "leathery" parchment-like material, and difficult to tear. The second cell (also 3.5 mm long) contained a mature larva, but no prey. The partition was a flimsy silken curtain. We suspect that the leathery appearance of the partition derived from fluids added to the silken curtain by the mature larva when it transformed to the prepupa.

A second nest was recently initiated, and contained a single egg suspended in a mesh of silken threads 2 mm from the base of a 22 mm long burrow; there was a flimsy silk curtain 2 mm further beyond it. The only other silk was a 1 mm meshwork of threads just inside the nest entrance

A third nest contained a teneral female, newly emerged from a single cell occupying the burrow 4–7 mm inside the entrance. Behind the cell the empty and unlined burrow extended another 20 mm. The outer partition to this cell was parchment-like, opaque brown and taut. The inner partition was a semitransparent matrix consisting of crisscrossed silken threads.

The fourth nest contained a single female wasp, but had no trace of any silk or brood, evidently having been only recently occupied.

Arpactophilus platycephalus.—Two nests of this flat-headed species were found on Magnetic Island, Qld. on 8 Nov. 1998. Both were in recently vacated green galls made by *Sphaleractis* sp. on *Persoonia falcata*. The first nest burrow was 23 mm long, with the basal 3 mm empty. It contained three cells in a linear series, with a single female resting in the burrow. The basal cell was 4.5 mm long and contained a new pink-eyed pupa in a delicate tan papery cocoon 3.5 mm long. Cell 2, also 4.5 mm long, contained a prepupa in a similar delicate cocoon. Cell 3 contained a small larva suspended in a few silken strands feeding on unrecognizable prey remains, with a single intact psyllid nymph also suspended in silken strands next to it. No silk was evident along the outer part of the burrow. The pupa of cell 1 desiccated, but the prepupa of cell 2 produced a female on 27 November.

The second nest collected at the same site held a female resting in front of a silk partition that completed the single cell at the base of the 30 mm long burrow. The cell was 4.5 mm long, and began 1.7 mm from the bottom, and contained a full-grown predefecating larva that was spinning its cocoon. It pupated 8 days later, and a female emerged after a further 11 days. The remainder of the nest burrow was empty, with no evidence of silk lining.

Both *A. platycephalus* and *A. similus* appear to be strictly solitary species that invade newly available galls of *Sphaleractis* on *Persoonia falcata*. They are relatively rare, compared to congeneric species nesting in the same galls at the same sites. For example, of 124 galls collected from a single tree of *P. falcata* at Kakadu NP, only 2 contained *A. similus* nests, while 20 contained nests of *A. kakaduensis* (see below).

Arpactophilus transversus.—Two species, *A. transversus* and *A. termes*, nest in abandoned termite galleries, both taken in Kakadu NP, NT. *Arpactophilus transversus* lines old termite galleries on rock surfaces with

silk. Because of the fragile nature of the nest material, nest details are unknown, but it may be a solitary species. Naumann (1983) recorded *A. transversus* as *Arpactophilus* sp. 48. In June 1984 we collected two additional females from termite galleries at the same locality. Two of three prey removed from their nests were psyllid nymphs of the lerp forming type, probably taken from *Eucalyptus* (det. K. L. Taylor, *in litt.*). The other prey was a cicadellid nymph tentatively identified as belonging to the subfamily Ulopinae (det. T. E. Woodward, *in litt.*). This is the only *Arpactophilus* species for which Cicadellidae are known as prey. Curiously, in May 1999, extensive searching of termite galleries on the same rock faces collected from in 1984 failed to turn up any nests of this species.

Arpactophilus termes.—This species is known from a single large nest collected at Kakadu NP, NT, that contained 14 females and five males. This nest was in a depression on a nearly vertical rock face about 1.5 m above the ground. The nest surface measured roughly 20 by 60 mm, but was irregular in shape and variable in depth to a maximum of about 10 mm and was inside and completely covered by termite gallery. There appeared to be two entrances about 40 mm apart. Less than 1 cm from one edge of the gallery was a mud cell of *Sceliphron formosum* (F. Smith) that contained a nest of *A. mimi* with three females.

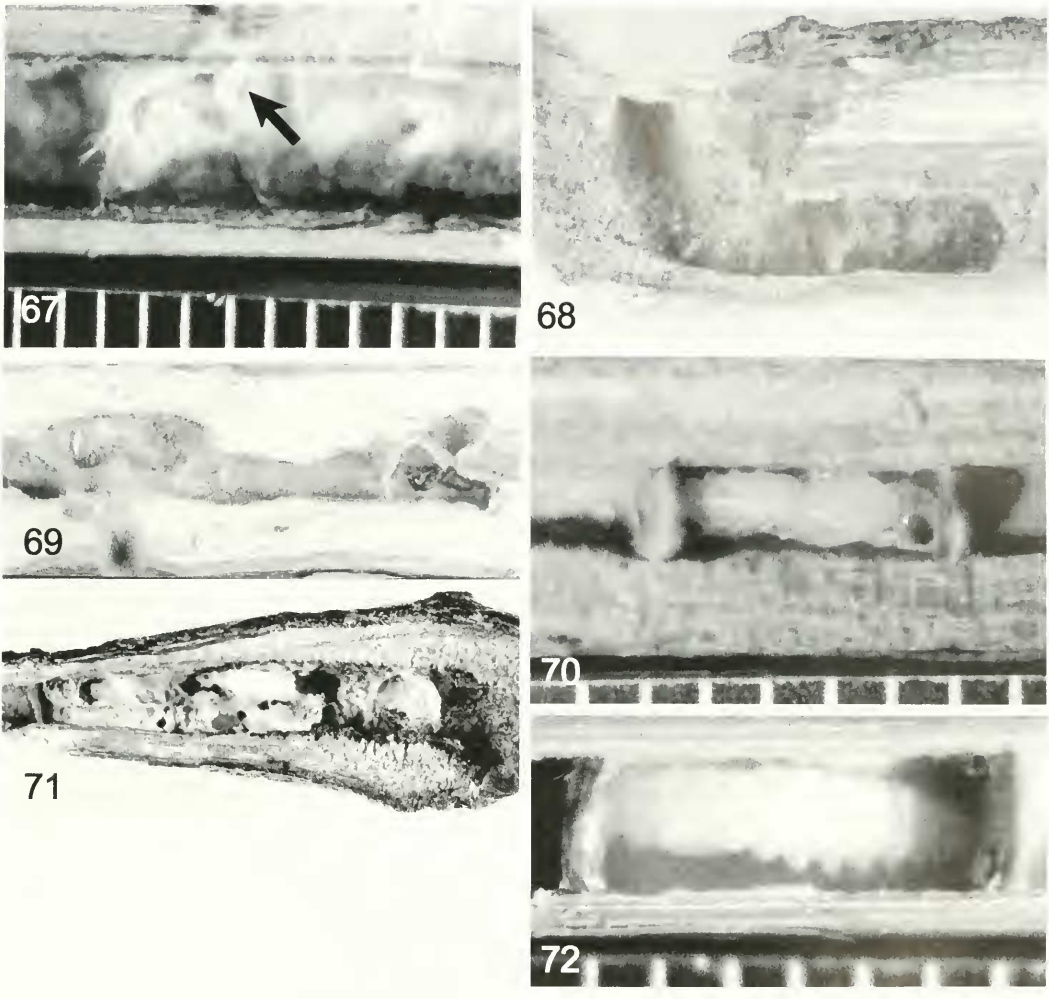
The termite gallery material was so fragile that it disintegrated during collection. Apparently there were several interconnected passageways that led to different parts of the nest, but definite structure could not be determined. In all, 33 silken cells were recovered, of which 14 contained progeny in various stages of development—five pupae, three prepupae, and six larvae of various sizes. Other cells were empty, and no eggs or prey were recovered. However, part of the nest contents were spilled in the field, with an estimated 10–12 cells lost.

Cells were found in clusters of one to five, tightly stuck to each other and to the nest material with silk. Extensive areas inside the termite gallery were lined with white silk and in some areas there were numerous white specks, presumed to be adult defecation. Mature larvae were enclosed in light tan silk cocoons, quite strong, although they could be readily torn with forceps.

If we assume that this was a single nest, then *A. termes* has by far the largest nests of any known species. In part this may reflect the fact that termite gallery is often extensive, potentially offering significantly more space for nesting than does a beetle burrow, mud wasp cell, or lepidopteran gall, all of which are of limited size.

Arpactophilus deakinus.—Three nests of this species were collected 24 January to 6 February, 1999 in the Canberra suburb of Deakin, ACT. Two nests were in stems of an ornamental azalea hedge planting, and the other in a pithy stem of *Hydrangea*. Both azalea and *Hydrangea* are exotic plants to Australia. The stems were 6–8 mm in diameter. All of the burrows were relatively short (27 mm, 23 mm, and 22 mm), 2.5–3.5 mm in diameter, and all were heavily lined with white silk. The two nests in azalea were in stems that had been previously used by other nesting hymenopterans; one was unidentifiable, but the other basal nest was that of *Nitela australiensis* Schulz (Matthews 2000b). This nest had three *A. deakinus* females present, and contained two cells, the basal one with a mature larva, and the second with a new egg (Fig. 67).

The other azalea nest contained four cells and three adult females. The basal cell contained a pupa with pink eyes, the second cell contained a new white pupa, the third cell a nearly mature larva with a partly consumed unidentified prey, and the fourth cell contained an egg. Cell lengths were 5–8 mm. Partitions were of



Figs. 67–72. Nests of *Arpactophilus* species. 67, Cell of *A. deakinus* in azalea stem containing an egg suspended in extensive silk matrix, part of which is laid back to better expose the egg. Egg measures 1.4 × 0.4 mm. Scale units are mm. 68, A beetle tunnel in a dead branch of *Acacia papyrocarpa* used as a nest by *Arpactophilus hursti*. One female emerged from cell in base closed by a leathery silk partition. 69, New nest of *A. magneticus* in beetle burrow in a small branch of *Mallotus phillipensis* (red kamulla) containing a single cell at end of lower right fork. The only silk was at the end of the burrow and a "curtain" across the burrow at the fork. Nest entrance at lower left. Burrow length 11 mm from entrance to end of lower right cell, and burrow diameter about 1 mm. 70, A naked pupa of *A. flavifrons* in a hollow 5 mm diameter stem of *Lophostemon grandiflorus*. Scale units are mm. 71, Nest of *A. kakaduensis* containing six cells in an old gall of *Sphaeractis parasitica* on *Persoonia falcata*. Note the silk enclosed pupal cells at the left (one partially torn open) and the extensive silk lining in the middle portion of nest burrow which measured 22 × 3 mm. Entrance at lower right. 72, A prepupa of *A. reticulatus* in bamboo. Scale units are mm.

flimsy silk, probably constructed or at least reinforced by the mature larva, and pupae were naked. The white sausage-shaped egg was suspended transversely across the burrow in a silk mesh (Fig. 67). The pupa in cell one was damaged when the nest was split open, but the progeny in cells two and three later emerged as adult females. The pupal stage took 21 days.

The third nest (in *Hydrangea*) contained two females, but no brood, and it appeared that one or both of the females was recently emerged from the nest. Thus there are at least two and perhaps three generations per year in Canberra. Because each of the three nests found contained more than one female, *A. deakinus* appears to be a cooperative nester, although its precise social status is unclear.

Arpactophilus hursti.—Figure 68 shows the empty nest of *A. hursti* in a short, old beetle burrow found in a small, dead branch of *Acacia papyrocarpa*. Three nests in similar branches were collected by Pam Hurst from the Lake Gilles Conservation Park in South Australia in May–June 1994, and another was found in a old beetle burrow in *Heterodendron* sp. The longest of these had a burrow 115 mm long and 4 mm diameter. No notes were made at the time of collection, the nests only being opened after the wasps were found emerged, and so no interior structure was identifiable.

Arpactophilus magneticus.—Seven nests of this diminutive species were discovered on Magnetic Island, Qld. between 16 September 1998 and 6 December 1998. All were in old convoluted beetle burrows in slender (7–10 mm in diameter) recently dead branches of various trees. Current beetle activity was noted adjacent to some nests, which suggests that none of the nests was more than a few weeks old. The trees were red kamulla *Mallotus philippensis* (Lam.) Muell.Ang (Euphorbiaceae), northern swamp mahogany *Lophostemon grandiflorus* (Benth.) (Myrtaceae), and *Neolitsea australiensis* Kostermans (Lauraceae). The number of cells per nest ranged from one to five; however, both of the nests found in December contained single cells with small larvae (Fig. 69), and their burrows lacked silk lining, suggesting that they were recently initiated, probably by solitary females.

One nest in *Lophostemon* contained two females and one male. Two nests in adjacent beetle burrows in another small branch of *Lophostemon* contained six adults, four females and one male (one adult escaped). Two nests in beetle burrows about 5 cm apart on a single branch of *Mallotus* contained one and two females respectively. Another nest in *Mallotus* contained a single female. The nest in *Neolitsea* contained a single male.

The beetle burrows varied from 1 to 3 mm in diameter, and some presented an oval cross section, which permitted resident adults to move freely alongside occupied cells. Unused parts of the beetle burrows were packed with frass. In some the wasps walled off distal sections of the frass-filled burrows, lining the cleaned portions with silk. Also, in some, the beetle tunnels extended in opposite directions from their exit hole (the nest entrance), and in these instances the wasps used both tunnel branches, arranging the cells in linear fashion. Immature stages in a given nest were all at distinctly different stages of development and there was never more than one egg in a nest. The cylindrical, white egg measured 0.85 × 0.4 mm and was suspended in silk mesh, occupying about 1mm of burrow with a flimsy silk "curtain" at the outer end. Completed cells were 4–7 mm long and separated with silk partitions. Pupae were in flimsy, translucent, silken cocoons, which were easily torn. Only one prey was recovered, an unidentified, immature psyllid found next to a small larva.

Older nest burrows (those with 3–5 cells) were extensively lined with silk. In one instance it was discovered that the silk was quite elastic. Several strands were grasped with forceps and stretched to more than twice their original length; when released they recoiled into wavy strands about half as long.

Males of this species are distinctive in possessing dense, silvery pubescence over the lower two-thirds of the face. This pubescence is postulated to be related to sex recognition and courtship.

Arpactophilus flavifrons.—One nest was found in an old beetle burrow in a slender twig (5 mm in diameter) of the northern swamp mahogany, *Lophostemon grandiflorus* (Myrtaceae) on Magnetic Island, Qld. on 28 October 1998. The 1.5–2 mm diameter burrow extended in both directions from the single entrance, 28 mm to the left side, and 49 mm to the opposite. One cell 3 mm long and containing a late pupa was at the base of the shorter left branch; this pupa dried out. The longer branch of the burrow contained three cells, ranging from 4.5–13.5 mm long. There was empty tunnel for 21 mm from the distal partition of the outermost cell to the nest entrance. The three cells contained a newly eclosed female, an adult male, and a naked pupa (Fig. 70) that emerged as an adult female 11 days later. The entire unused sections of burrow on both sides of the entrance were silk lined. Additional evidence that this nest was relatively old was that beyond the active three cells was an old moldy *Arpactophilus* thorax, sealed behind a silk partition.

A second incipient nest was found in a slender node of bamboo on Magnetic Island on 14 December 1998. The nest burrow was 57 mm long and 1.5 mm in diameter. There was a single empty cell 5.5 mm long at the bottom of the burrow, and one female wasp was resting in the burrow.

Arpactophilus kakaduensis.—Found only in Kakadu NP, NT, and predominantly nesting in empty woody galls of *Sphaleractis parasitica* on *Persoonia falcata* (Proteaceae), this wasp was relatively common. From one tree 20 nests were obtained from a sample of 124 old (prior year) woody galls. Most of the other galls were unoccupied, so that lack of potential nest sites did not appear to limit populations. Two nests were found in smaller, unidentified galls (9–12 mm long and 2–3 mm in diameter) on an unidentified tree.

Twenty-four nests collected 20–24 May 1999 contained up to 5 adult females and up to 10 cells (average of 3.4 cells/nest). Burrows of nests in *P. falcata* galls were from 12–30 mm long and 2–4 mm indiameter. Pupae were enclosed in flexible, soft, white, silken cocoons, easily torn with forceps (Fig. 71). Cells were usually clustered in the basal section of the gall. Most of the nest interiors were extensively silk-lined, especially in older nests with more than two cells, and cells were separated with silk partitions. Summarized brood contents of 69 occupied cells consisted of 6 eggs, 20 larvae, 11 prepupae, and 32 pupae. In the largest nest containing 10 cells and 5 females, two eggs were present, suggesting that two or more females may have been ovipositing.

In the plastic bag used to transport the *Persoonia* galls to the laboratory, two male *Megalyra* sp. (Megalyridae) were discovered. Because another species of *Megalyra*, *M. troglodytes* Naumann, is recorded as a parasite of *A. mimi* from the same locality (Matthews and Naumann 1988), we suspect that this apparently undescribed species may attack *A. kakaduensis*. However, no direct evidence of parasitism was found in the nests sampled, but these two individuals must have been inside one or two galls when the sample was collected. The specimens are deposited in the ANIC.

Arpactophilus reticulatus.—This species is widely distributed across northern Australia from the Kimberley Region, W.A. to Kuranda, Qld. in the east. Based on our observations, *A. reticulatus* is the most catholic of any of the known species in its choice of nest sites. We found 14 nests in pre-existing cavities in five species of plants and in diverse habitats from bushland to urban yards.

Thirteen nests were collected on Magnetic Island, Qld., and one on the campus of James Cook University, Townsville, Qld. between 17 September and 6 December 1998. Six nests were found in internodal sections of bamboo (Fig. 72). Four of these were constructed in the outer portion, with debris from prior hymenopter-

an nests walled off in the basal portions. Four nests were found in woody galls of *Sphaleractis* sp. on *Persoonia falcata* (Proteaceae). The other nests were in old beetle burrows in slender dead branches on three trees: northern swamp mahogany, *Lophostemon grandiflorus* (Myrtaceae) (one nest); the native mulberry, *Pipterus argenteus* (G. Gorster) Wedd. (Urticaceae) (2 nests); and the Brazilian pepper tree, *Schinus terebinthifolius* Raddi (Anacardiaceae) (one nest). The latter was found on the JCU campus.

Nest tunnels were 1.5–3.0 mm in diameter, and varied in length from 13–97 mm. The amount of silk lining of the burrows varied from extensive in *Persoonia* galls to little in bamboo stems. Eight nests contained no adults when collected, five contained single females, and one contained two females. Curiously, this latter nest was only recently initiated, containing a single cell with an egg (1.4 × 0.5 mm) suspended in silk mesh. With this possible exception, it appears that *A. reticulatus* is essentially a solitary wasp.

Number of cells ranged from 1–5/nest (average 2.5). Cell lengths varied widely, but cells with pupae or prepupae were 4.5–6.5 mm long with the pupae in flimsy cocoons. Silk spun by larvae was distinctly tan colored. Three of the six larvae had fresh psyllid nymphs (unidentified) suspended in silk adjacent to them, two being provided with two prey and the other with three prey. Several progeny were successfully reared, yielding four males and seven females.

Two nests of this species, one on Magnetic Island in a *Persoonia* gall and the other from the JCU campus in a *Schinus* branch, were parasitized by *Calosota* sp. (Eupelmidae). In each nest all three cells were parasitized, yielding five females and one male parasite. This chalcidoid attacks the larval or pupal stages of its host. *Calosota* is a cosmopolitan genus recorded from various stem-nesting bees and wasps (Noyes 1998). In Australia it has also been reared from *Psenulus interstitialis* Cameron on Magnetic Island (Matthews 2000a).

DISCUSSION

All known species of *Arpactophilus* appear to be progressive provisioners. All apparently suspend their relatively large eggs in a silken meshwork. So far as known, all prey on nymphs of psyllids (rarely tingids or cicadellids) which are placed individually enmeshed in silk adjacent to the feeding larva. All known species appear to have more than one generation per year. All appropriate various types of pre-existing cavities, ranging from old termite galleries to abandoned beetle burrows and lepidopteran galls or hollow stems in a variety of plants. Four species (discussed below) nested in abandoned lepidopteran galls in geebung, *Persoonia falcata* (Proteaceae), a widely distributed tree common across northeastern Australia. Previously, *A. mimi* Naumann was recorded from old mud wasp nests (Matthews and Naumann 1988). Interestingly, none of the species described herein were found to have entrance guards as in *A. mimi*. Nor did any of the species have a discernible odor like the lemony odor noted from the heads of *A. mimi* (Matthews and Naumann 1988).

Although at least two of the known Australian species, *A. mimi* (see Matthews and Naumann 1988) and *A. termes*, appear to be socially advanced, at the other end of the spectrum, at least four seem to be strictly solitary: *A. platycephalus*, *A. similus*, *A. flavifrons*, and *A. reticulatus*. With the presence of numerous adults in a nest, *A. termes* is possibly the social equivalent of some eusocial *Microstigmus*, but more study is required since only one nest of *A. termes* was found. In the case of *A. mimi*, other solitary wasps (including conspecifics) and bees competing to reuse the old mud cells of *Sceliphron formosum* were postulated as an important selective pressure favoring nest guarding as empty mud cells were essentially non-existent at Kakadu (Naumann

1983; Matthews and Naumann 1988). In contrast, empty lepidopteran galls on *Persoonia falcata* at Kakadu were relatively common. In one sample from a single tree, 93 of 124 old dead galls (75%) were unoccupied; in another sample from six trees 29 of 68 old galls (43%) were empty. This suggests that interspecific competition from competing "renting" species may not be as strong in the relatively unsaturated gall habitat. Also, the availability of potential nest sites may relax the pressure from conspecifics, postulated as an important force driving sociality in *A. mimi* (Matthews and Naumann 1988). Thus, the discovery of apparently solitary *Arpactophilus* species is perhaps not surprising.

In the arboreal setting of most species discussed here, foraging ants are ubiquitous and ant predation would seem to constitute a major threat to *Arpactophilus* nests. However, no instances of ant predation were observed. Possibly the silk used to line the burrow and suspend the eggs and prey items in the nest contains chemicals that are either neutral or repellent to foraging ants. Various species of ants were commonly encountered in the lepidopteran galls on *Persoonia falcata*, even adjacent to galls occupied by *Arpactophilus*. Thus, ants may compete for potential nest sites, although where these galls were relatively numerous, as was true at Kakadu National Park, empty unused galls were common.

The incidence of parasitism was also extremely low. Only one species of parasite was reared from any of the *Arpactophilus* species discussed here. *Calosota* sp. is a generalist species known to attack various stem nesting wasps and bees. It was reared from two of 14 nests of *A. reticulatus*, a solitary species. Presumably the parasite oviposited while the female was away, since all the larvae or pupae in each nest were parasitized. Previously, the only parasite recorded from any *Arpactophilus* was *Megalyra troglodytes* Naumann (Megalyridae) which attacked *A. mimi* (Matthews and Naumann 1988), but the incidence of parasitism was extremely low (5 of 109 cells parasitized, 4.6%). Such low levels of parasitism are consistent with the trend in other members of the Spilomenina (discussed in Matthews 1991), but contrast strikingly with those found in other sphecids, such as *Sceliphron* which typically experiences 20–40% parasitism or more (Naumann 1983, Smith 1979), suggesting that the increased level of parental care observed in *Arpactophilus* is a highly successful strategy.

Presumably parental care extends until all the brood have emerged, as no outer nest entrance closures were found, and in several instances active nests contained only late pupae, with no younger brood stages present. In most species for which nests are known, brood development suggests that only a single adult is reproductive because every immature individual present was at a distinctly different stage of development. (The only exception was an unusually large 10-celled nest of *A. kakaduensis* that contained 5 adult females and had 2 eggs.)

Nothing has been recorded on the biology of the larger *Arpactophilus* species (*A. arator*, *A. bicolor*, *A. deserticolus*, *A. kohlii*, *A. steindachneri*, and *A. sulcatus*), other than a description of the larva of *A. steindachneri* by Evans (1964). Evans gives as his source for this material specimens collected by C. D. Michener at Yaamba, Queensland in August 1958. Michener (*in litt.*) says his field notes for the date of the specimens are uninformative as to details of nests or habitat. However, one individual of *A. steindachneri* in the Queensland Museum, collected by H. Hacker from Brisbane, Queensland, 6/7/15, bears a handwritten label "adult dug out of sand bank". This report of apparent soil nesting needs confirmation; in particular it needs to be determined whether nests are dug *de novo* or made in preexisting tunnels. If indeed some species nest in soil, then *Arpactophilus* would display one of the broadest

nesting niches of any sphecid, but still not unique. Another member of the Spilomenina clade, *Spilomena*, has at least one species that excavates nests in the soil (McCorquodale and Naumann 1988), although other known members of *Spilomena* nest in preexisting cavities.

In both *Spilomena* and *Arpactophilus* the most striking biological attribute is their use of silk in nesting. The use of silk as a sort of "glue" has meant that potentially any substrate can be remodeled and sculpted to serve as a nest. In the other large genus of Spilomenina, the Neotropical *Microstigmus*, various species use silk to fashion nests of plant hairs, rock bits, or wood chips (Matthews 1991). The postulated energetic expense of silk production has been suggested to be the basis for the unique social evolution in this clade (Matthews 1991).

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